AD 602969

PARTICLE SIZE ANALYZER INSTRUCTION MANUAL

FOR

U.S. ARMY CHEMICAL CORPS BIOLOGICAL LABORATORIES
FORT DETRICK, MARYLAND

CONTRACT DA-18-064-CML-2793

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PROCESSOR:

TSL-107-10/64

The photometer uses the light scattering principle for the detection of particles in the sample stream. Air is drawn into the intake nozzle of each section of the photometer and from there into a dilution valve where it is mixed with filtered air, if necessary, to reduce the concentration. From the dilution valve, the air is drawn into a detection chamber where a short length of the stream is illuminated by light projected from the filament of a small lamp. The two sections of the photometer use the same lamp with the light being projected onto the fast stream after being incident on the slow stream. Filtered body air flows through each section of the photometer to maintain streamlined flow of the two sample streams. In each section the incident light is at right angles to the sample stream. A photomultiplier tube, with its lens system, is located in the same plane as the light source and on an axis 135° from the illumination. Light scattered from a particle in the sample stream is focused onto the cathode of the photomultiplier, resulting in a pulse of current related to particle size. Pulses from each photomultiplier are amplified by separate pre-amplifiers in the photometer housing and connected to the analyzer through a shielded cable.

The wiring diagram of the photometer assembly is shown in Drawing 1360-D-34, reproduced in the Appendix.

Pulse Height Discrimination and Pulse Counting

The pulses from the preamplifiers are amplified further by separate amplifiers in the analyzer and stored for about 350 microseconds in peak storage circuits. The stored pulse is applied to the array of discriminators that define the particle size channels. The discriminator action opens the gate circuit of the appropriate channel according to particle size, and a gate pulse generated during the storage time enters that channel. The gate pulse is amplified in the appropriate channel and enters the counting circuits. The end of the gate pulse resets the peak storage circuit.

The counting circuit of each channel produces a d-c voltage proportional to pulse rate and thus proportional to particle concentration. The d-c voltages are given power amplification by buffer amplifiers whose outputs are connected to the external recorders. Figure 1 shows a system diagram of the analyzer circuits.

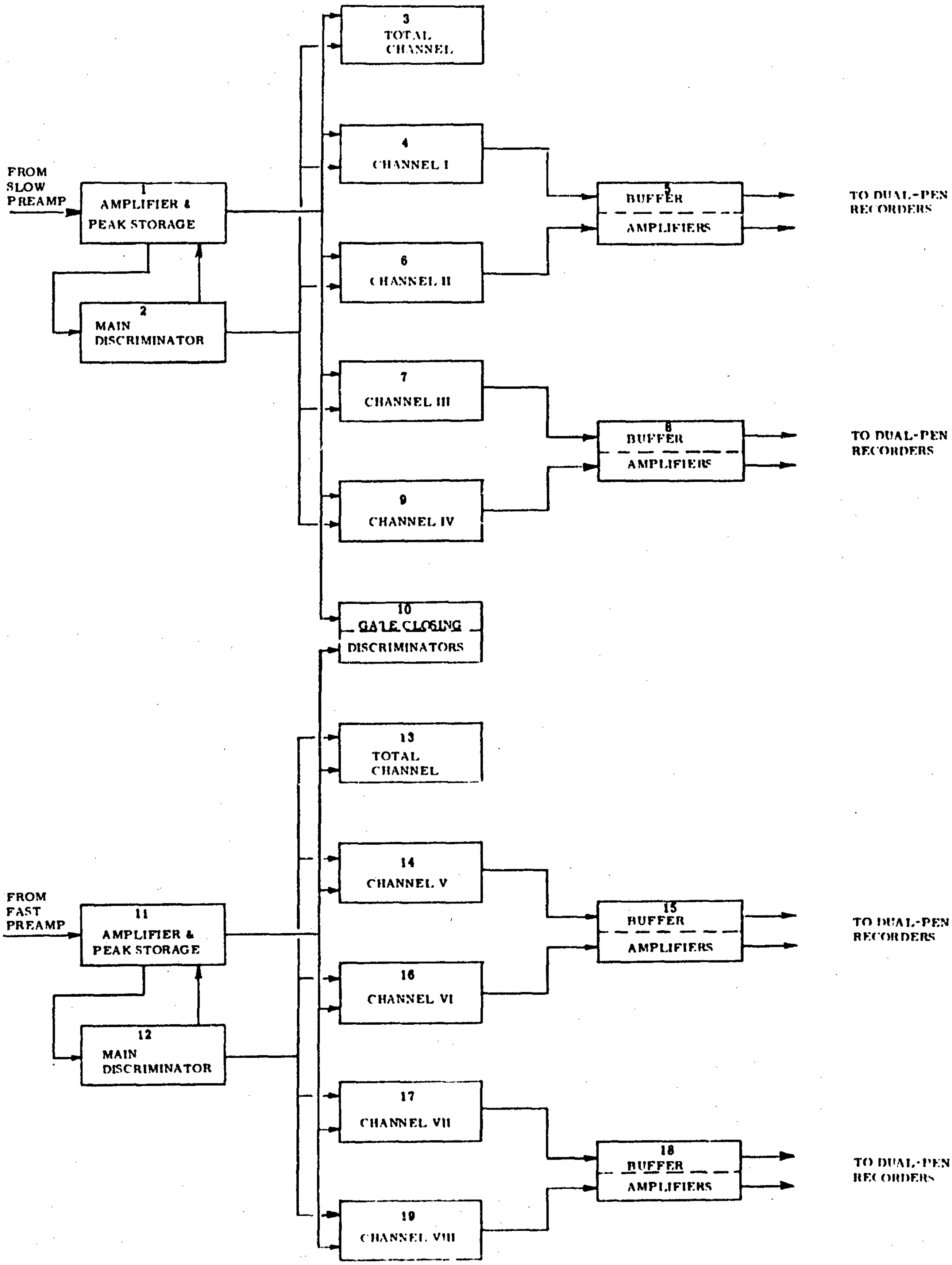


FIG. 1 ANALYZER SYSTEM BROKEN DOWN BY CIRCUIT BOARDS

OPERATING INSTRUCTIONS

The two units making up the particle size analyzer must be used in the combinations in which they have been calibrated. Initially, the following combinations have been calibrated together:

Instrument No.	Photometer No.	Analyzer No.
P2-A1	2	1
P6-A2	6	2
P1-A3	1	3
P5-A4	5	4
P3-A6	3	6
P4-A5	4	5

Preliminary Connections

Before operating the instruments the following cable connections must be made:

1. Connect the photometer to the analyzer with the cable terminating in two 14-pin, MS-type connectors. Six 6-foot cables and one 155-foot cable have been provided.

2. Connect the analyzer to four dual-pen recorders, using the 17-pin, MS-type connector.

3. Connect the analyzer to a 6-volt battery or other source that will provide 6 volts at approximately 6 amps using the 3-pin, MS-type connector. Cables containing the proper mating connectors and battery clamps are provided.

4. For remote on/off control, connect the analyzer to a set of contacts rated at approximately 1/2 ampere using the 2-pin, MS-type connector.

Controls

The controls on the instrument consist of the following:

1. Power Switch. - The power switch is located on the analyzer and is shunted by the contacts of a power relay, which is

operated by closure of the remote control contacts. When the instrument is turned on either manually or remotely, an indicator lamp is energized.

2. Dilution Valve Control. - The dilution valves on the photometer are geared together and are adjusted by a single control knob. The dials are calibrated at dilution factors of 1, 2, 5, and 10. The dilution factor of 1 corresponds to no dilution, and the factor of 10 corresponds to 9 parts filtered air and 1 part sample air. The reading of the meter or recorder is multiplied by the dilution factor to determine concentration.

3. Function Switch. - The function switch is on the photometer and is used to select the parameter to be monitored by the meter also located on the photometer. The switch has the following positions:

   T-1 - slow total channel concentration, normally 200,000 particles per liter, full scale.

   T-2 - fast total channel concentration, normally 50,000 particles per liter, full scale.

   L - lamp intensity, which is an arbitrary value that should be recorded after each calibration.

   A - battery voltage, 10 volts full scale.

   E_L - lamp voltage, 10 volts full scale, nominally 2.8 volts.

   H-1 - high-voltage supply voltage for the slow section, 2000 volts full scale, nominally 900 volts.

   H-2 - high-voltage supply voltage for the fast section, 2000 volts full scale, nominally 900 volts.

4. Concentration Sensitivity Switches. - Ten miniature toggle switches are located inside the analyzer on the right side. They control the full-scale range of the counting circuits in the eight size channels and the two total channels. In the "High Concentration" position, the counting circuits have full-scale ranges of 100 pulses per second and in the "Low Concentration" position, 20 pulses per second. For the standard flow rates, 20 pps full scale corresponds to 40,000 ppl x dilution factor for the slow section and 10,000 ppl x dilution factor for the fast section.

Operating Procedure

1. Make the preliminary connections described above and turn on the recorders.
2. Turn the function switch to T-1.
3. Turn on the power switch.
4. Set the dilution valve control to the lowest dilution factor obtainable with the meter reading on scale.
5. Turn the function switch to T-2 and be sure that the meter reads on scale.
6. Set the concentration sensitivity of each channel.

CALIBRATION PROCEDURE

There are four parameters that must be calibrated in order to insure accuracy of concentration and particle size measurement. These are flow rate, dilution valve setting, pulse rate setting of the counting circuits, and setting of the pulse height discriminator circuits for the proper particle size. The first three settings determine the concentration following the formula:

$$\text{Concentration} = \frac{\text{Dilution factor x pulse rate}}{\text{Flow rate}}$$

The dilution valve is calibrated in terms of dilution factor, and dilution factors of 1 through 10 correspond to zero dilution through 9:1 dilution. Undiluted full-scale concentration for the slow section is 200,000 particles per liter. This value is obtained with the counting circuit calibrated to read full scale on 100 pulses per second and with a flow rate of 30 milliliters per minute. The flow of the fast section is 120 milliliters per minute, and undiluted full scale corresponds to 50,000 particles per liter. The range change switches for each channel cause the counting circuit to read full scale on approximately 20 pulses per second, corresponding to 40,000 particles per liter for slow channels and 10,000 particles per liter for the fast channels.

Preliminary Checks

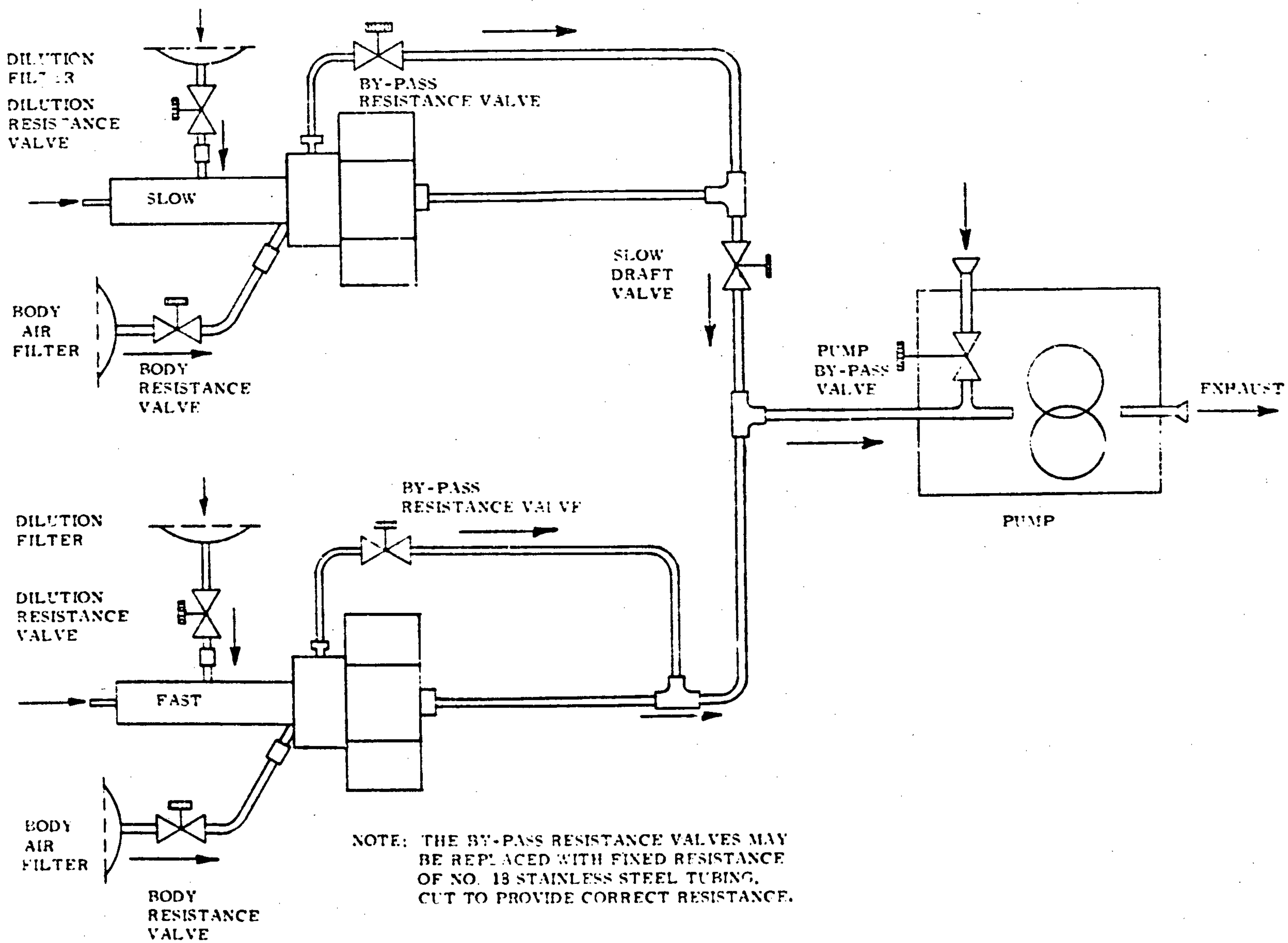
Before recalibrating any part of the instrument, the function switch should be turned through the different monitoring positions, and the value of each parameter should be checked. The outputs of the +12 volt and -22 volt supplies should also be checked with an auxiliary voltmeter.

Flow Calibration

The flow system is shown in the diagram of Figure 2. The flow in each section of the photometer can best be measured by connecting a graduated tube to the inlet nozzle and timing the passage of a soap bubble down the tube. To correctly adjust the flow rate in both sections of the photometer, first set the fast flow by means of the pump by-pass valve. Then set the slow flow by adjusting the slow draft valve.

Dilution Calibration

To set the dilution valve, a homogeneous aerosol, preferably of a single particle size, should be sampled. First set the dilution valve at the X1 dilution factor and record the concentration. Then change to the X2 position and record. Next compare the X5 setting to the X2 setting, and finally compare the X10 setting to the X5 setting. Especially for the fast section, it is necessary to make certain that the concentration of the aerosol has not changed between readings. If the concentration measurements are not in the correct ratio, the flow passages are probably dirty and should be cleaned by air from a squeeze bulb, or by a probe, or both. If the readings remain incorrect or if the readings for the slow photometer



NOTE: THE BY-PASS RESISTANCE VALVES MAY BE REPLACED WITH FIXED RESISTANCE OF NO. 18 STAINLESS STEEL TUBING, CUT TO PROVIDE CORRECT RESISTANCE.

FIG. 2 AEROSOL PHOTOMETER FLOW DIAGRAM

do not correspond to those for the fast photometer, the gearing may have slipped. In this case, check the infinite dilution point of each photometer section observing the pulses on an oscilloscope. The mid-point between the two positions where the dilution valve is just barely open, as observed on the scope, is the infinite dilution point. If these mid-points are not the same on each photometer, set the fast photometer at the index point, loosen the fast worm gear, and adjust the dilution knob until the slow photometer is at the index point. Then retighten the worm gear.

Pulse Rate Calibration

Before calibrating for pulse rate, there are three zero adjustments that should be checked if the recorders do not read zero with no pulses applied. The first is the recorder zero or meter zero in the case of the total channels. These should be checked with the instrument off. The second is the buffer amplifier zero for each channel. These should be checked with the channel boards removed. They can be adjusted by means of potentiometers located on the buffer amplifier boards. The third check is the zero of each counting circuit. If the recorders and buffer amplifiers have been zeroed, the recorder readings with the channel boards installed will be an indication of counting circuit zero. There is no control for zeroing the counting circuit, and a significant reading will indicate a faulty circuit. A zero drift of a few percent can be compensated by the buffer amplifier zero or recorder zero controls if desired.

To check the calibration of the counting circuits, connect a pulse generator to the input of the preamplifier. The pulse height should not be greater than 1/2 volt. A one-to-two millisecond pulse should be used for the slow section and a 100-to-200 microsecond pulse for the fast section. By adjusting the pulse height, the counting circuit in each of the channels can be made to operate successively. With the range switch in the X1 position, the output of the counting circuit should be -10 volts, with an input of 100 pulses per second. The pulse rate required to give full-scale voltage can be adjusted by means of the potentiometer, R1, located on each channel board. The output voltage should be measured at the collector of Q_8 on the channel board.

With the range change switch in the X5 position, the counting circuit output should be -10 volts, with a pulse rate 1/5 the previous pulse rate. This value is determined by the emitter resistor of the output transistor of the counting circuit.

A negative 10 volts at the output of the channel board should give -5 volts at the emitter of Q_6 or Q_{12} on the buffer amplifier board and should cause the recorder to read full scale. A rheostat in series with each recorder input can be used to set the recorder correctly.

Particle Size Calibration

The apparent size of a particle depends on the intensity and alignment of the illuminator, the alignment of the detector optics, the gain and alignment of the photomultiplier, the gain of the amplifiers, and the settings of the various discriminator circuits. A quick check of particle size calibration can be obtained by sampling 1.17 micron polystyrene particles available from Dow Chemical Company. The particle suspension as received should be diluted about 100:1 with distilled water and aerated with a nebulizer into a container that has been previously cleaned with filtered air.

For the 1.17 micron check the channel boundaries should be adjusted by means of the two miniature toggle switches located on the circuit board panel of the analyzer. In the "on" position these switches change the boundaries of the last channel of the slow section and the first channel of the fast section to count particles in the size range 1.0 micron to 1.35 microns. The 1.17 micron particles fall in the center of these channels and provide a means of setting amplifier gain. The amplifier of each section should be set to give a maximum reading in the calibration channel when sampling 1.17 micron polystyrene. The amplifier gain is adjusted by means of the potentiometer on the amplifier board in the analyzer. Care must be taken to prevent erroneous settings due to the changing concentration of the aerosol being sampled.

A more complete calibration requires the use of several sizes of polystyrene particles. First the photometer calibration curve should be checked with polystyrene particles and then, using the calibration curve, the discriminators should be set to operate from the appropriate pulses from a pulse generator. The initial calibration curves for the six instruments are shown in Figures 3 through 9. The curves for the slow sections of each instrument are different, but the same curve is used for the fast sections. The curves give the pulse height at the arm of the potentiometer on the amplifier board for different sizes of polystyrene particles.

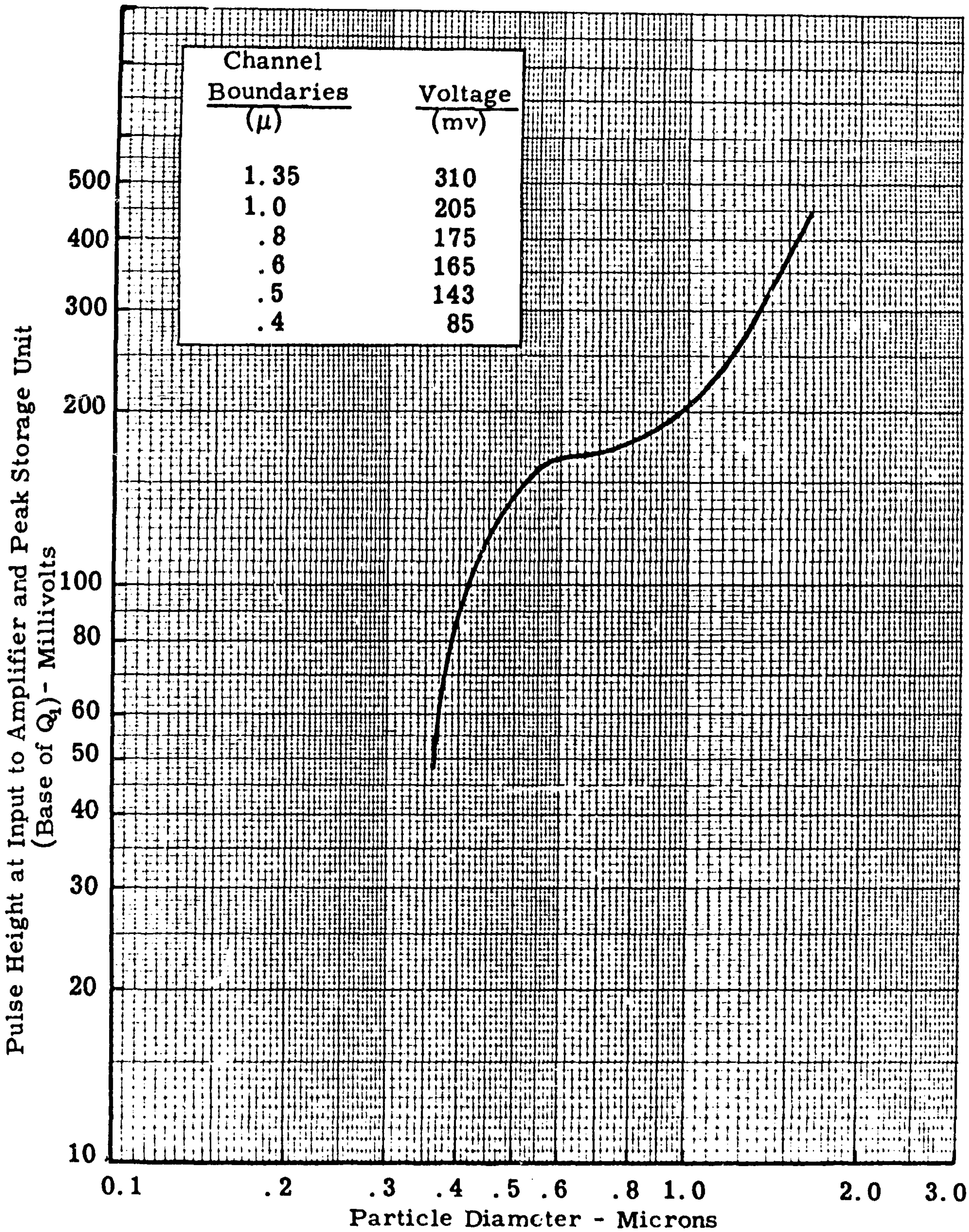


Fig. 3 Calibration Curve for Photometer P-1, Slow Section

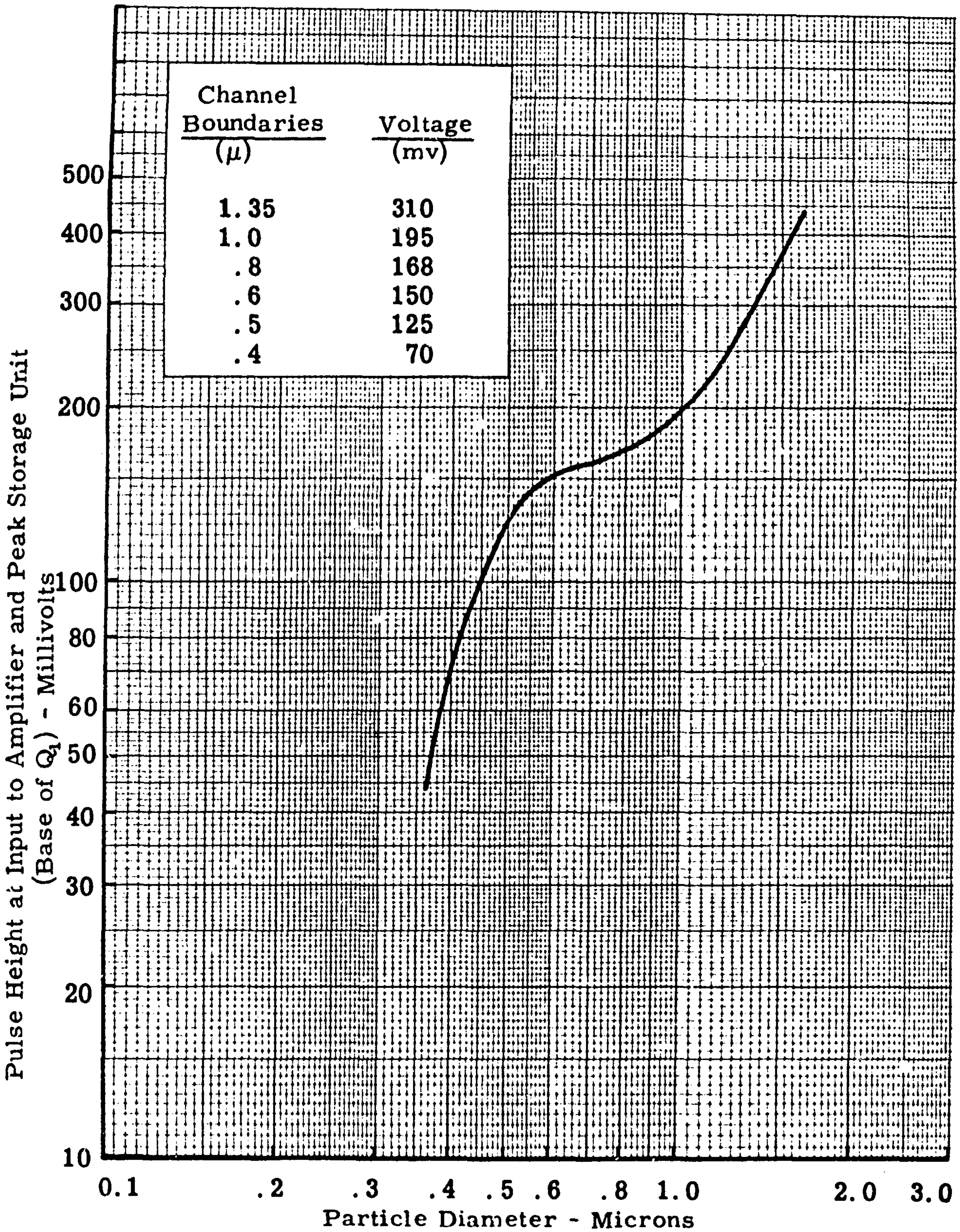


Fig. 4 Calibration Curve for Photometer P-2, Slow Section

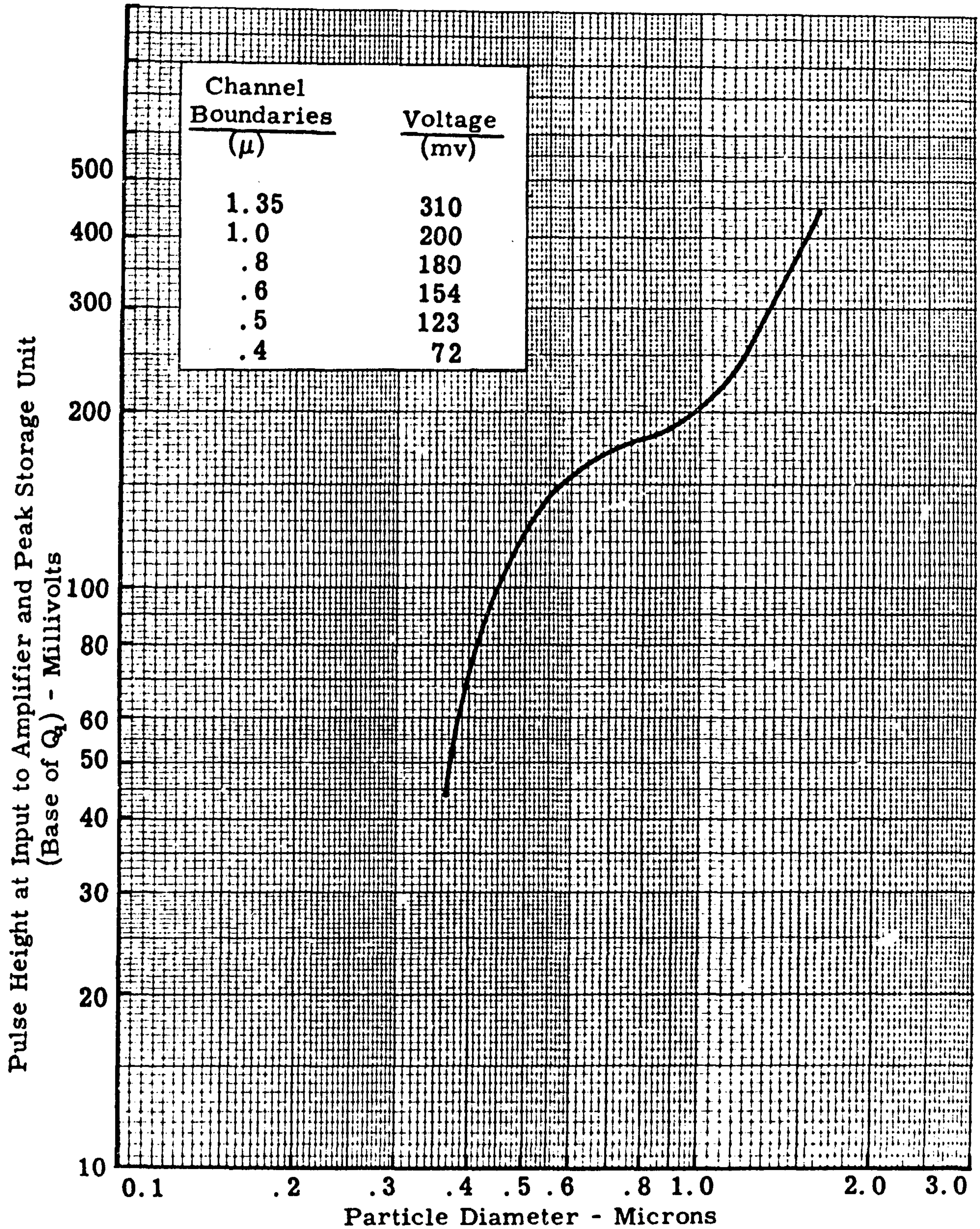


Fig. 5 Calibration Curve for Photometer P-3, Slow Section

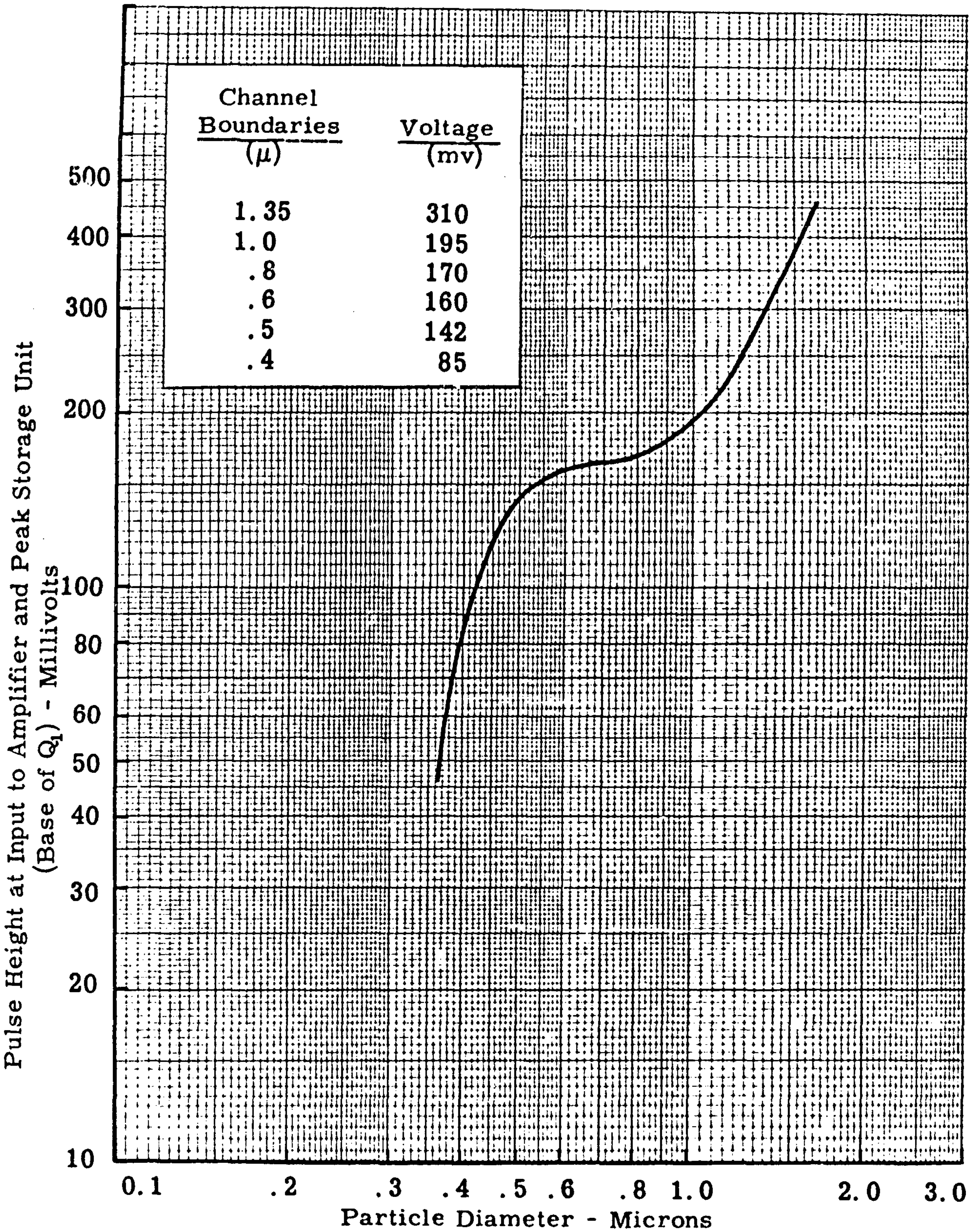


Fig. 6 Calibration Curve for Photometer P-4, Slow Section

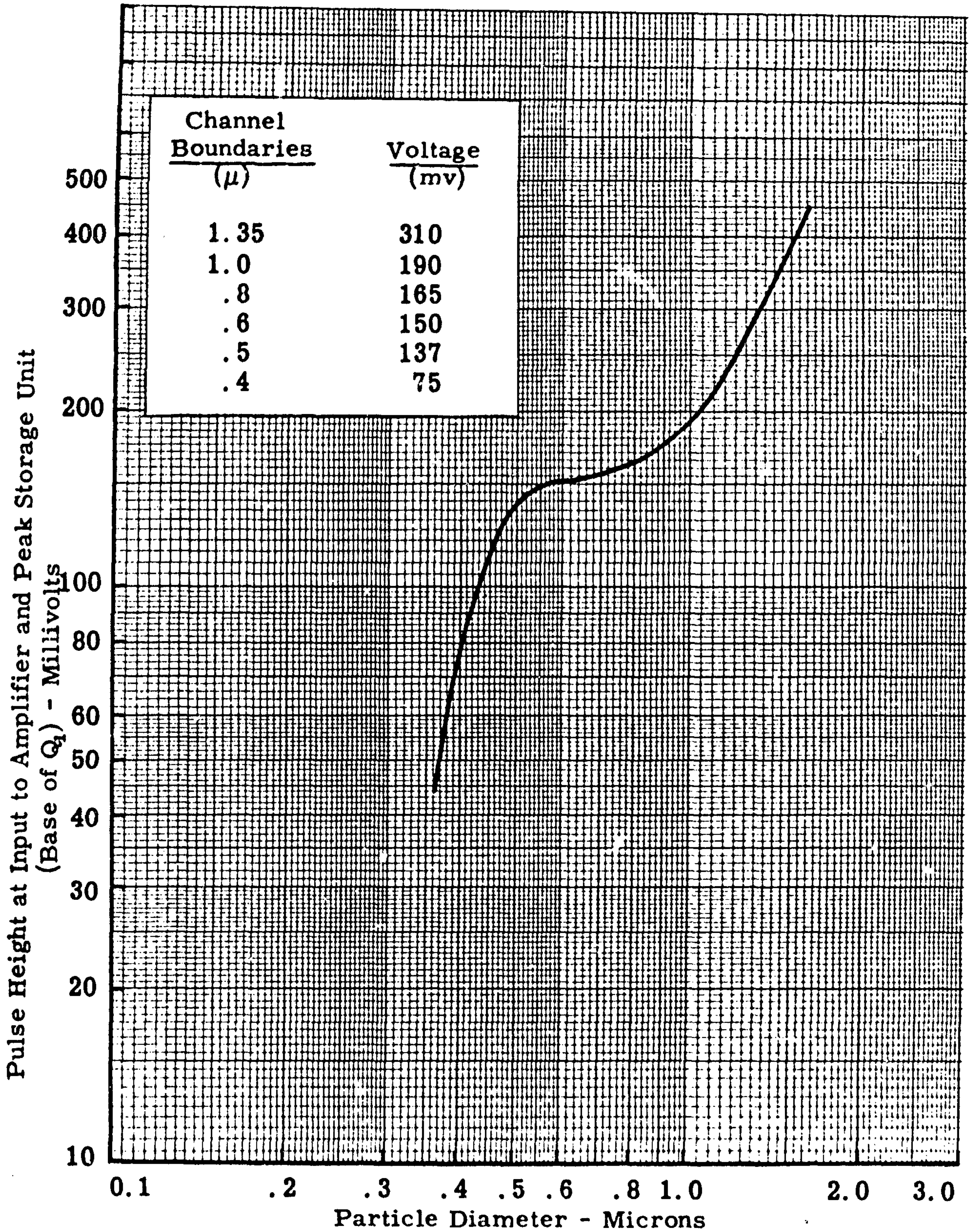


Fig. 7 Calibration Curve for Photometer P-5, Slow Section

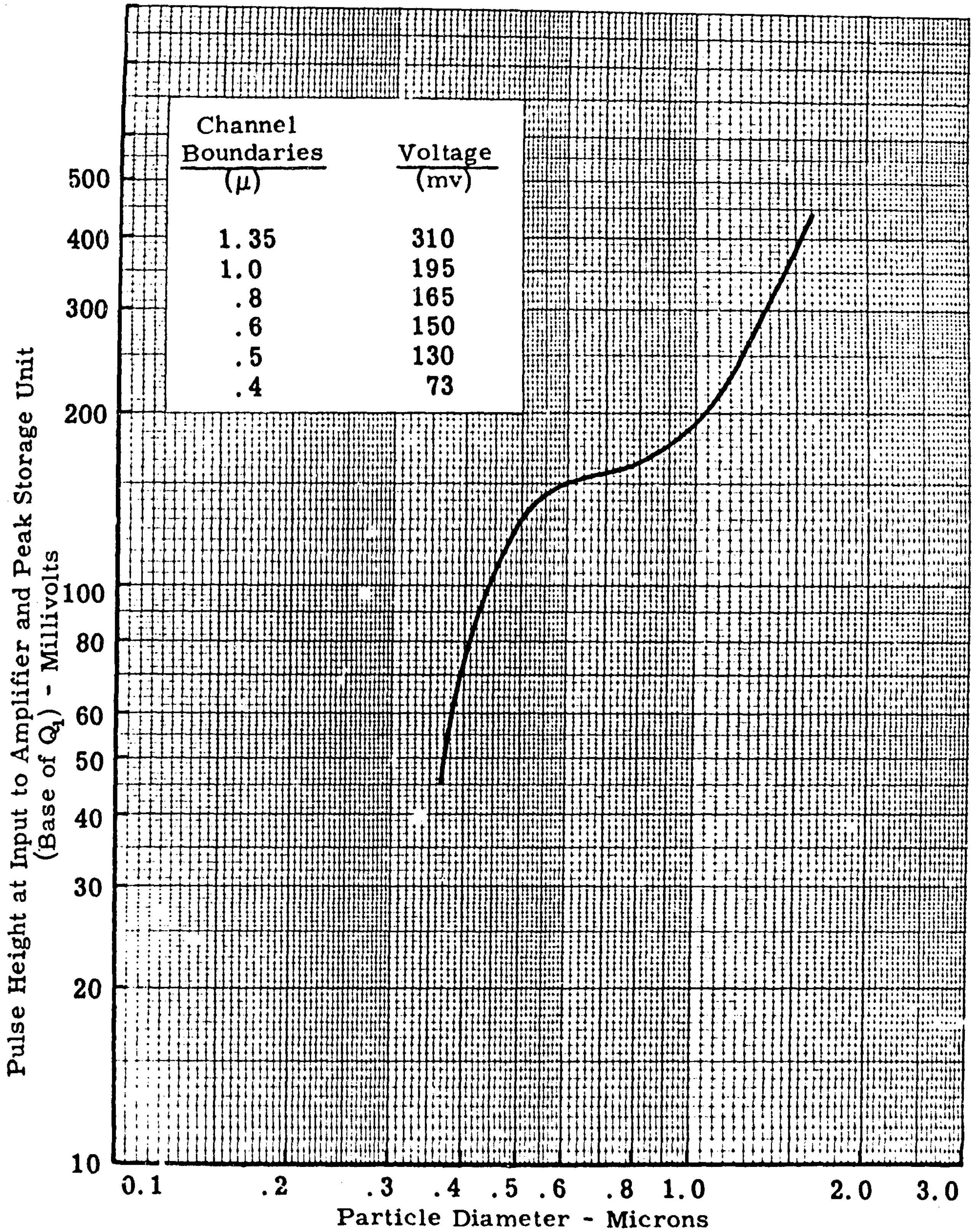


Fig. 8 Calibration Curve for Photometer P-6, Slow Section

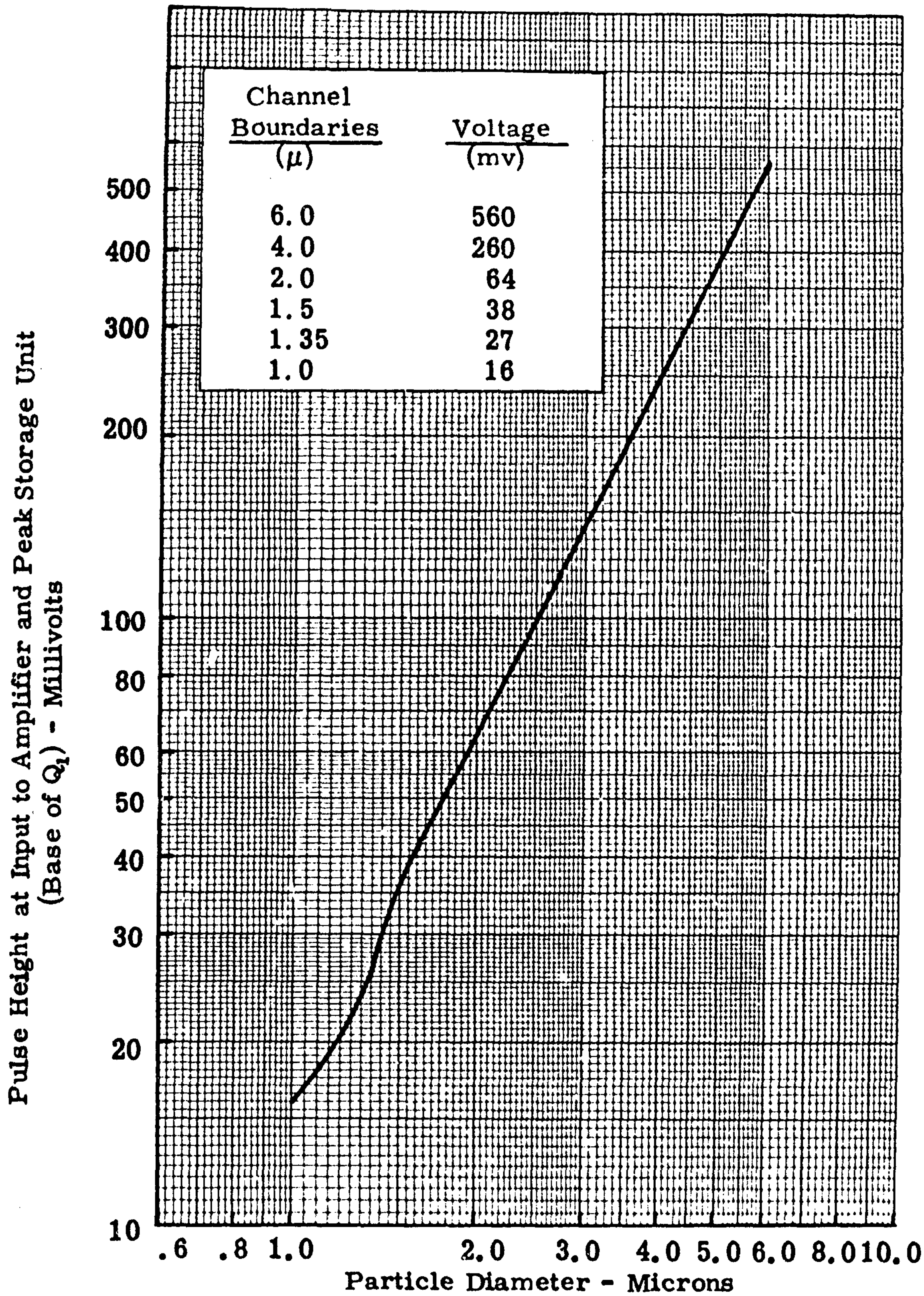


Fig. 9 Calibration Curve for All Photometers
Fast Section

The detailed particle size calibration procedure is as follows:

1. Attach an oscilloscope to observe the stored pulses in the slow section of the instrument.

2. Observe the average height of pulses when 1.17 micron polystyrene is being sampled.

3. Connect a pulse generator to the input of the preamplifier and adjust to give the same stored pulse height.

4. Measure the pulse height at the arm of the potentiometer on the amplifier board (base of Q_1) and, if necessary, reset the potentiometer to obtain a pulse height of 240 millivolts. In the same way measure the pulse height for various sizes of polystyrene.

5. Draw a curve of pulse height versus particle size and compare this to the calibration curve furnished. If the new curve does not agree with the previous one, due perhaps to lamp aging, the new curve should be used for setting the discriminators.

6. Observe on the curve the pulse height corresponding to the channel boundaries for each channel, and, using a pulse generator, set the channels at these values. The arm of the potentiometer is used for the test point. The channel boundaries can be observed by the deflection of the recorder pens with increasing pulse height.

7. Repeat this procedure for the fast channels setting the pulse height at 19 millivolts for 1.17 micron particles. Unless uniform particles larger than 1.8 microns are available, it will be necessary to extrapolate the curve at the 1.8 micron point, using a square law or a slope of 2 on logarithmic paper.

8. The channel boundaries are adjusted by sliding the taps on the resistance elements located on the rear of the circuit board panel. The taps should be loosened and slid gently

to prevent damage to the resistance element or the tap connection, and should be retightened with only a moderate pressure.

The channels have been set initially as shown in Table I. Pulse heights for the boundaries are given on the calibration curves.

Table I

Channel	Normal Boundaries	Boundaries with Calibration Switches On
Slow Total	0.4μ - 1.0μ	0.4μ - 1.35μ
1	0.4μ - 0.5μ	0.4μ - 0.5μ
2	0.5μ - 0.6μ	0.5μ - 0.6μ
3	0.6μ - 0.8μ	0.6μ - 1.0μ
4	0.8μ - 1.0μ	1.0μ - 1.35μ
Fast Total	1.0μ - 6.0μ	1.0μ - 6.0μ
5	1.0μ - 1.5μ	1.0μ - 1.35μ
6	1.5μ - 2.0μ	1.35μ - 2.0μ
7	2.0μ - 4.0μ	2.0μ - 4.0μ
8	4.0μ - 6.0μ	4.0μ - 6.0μ

MAINTENANCE INSTRUCTIONS

The six particle analyzers have parameters which vary from unit to unit. The important ones are listed in Table II. "Fast Exhaust" and "Slow Exhaust" refer to the vacuum in inches of H_2O at the outlet of the fast and slow photometers. "Lamp Intensity" refers to the reading of the current in the silicon cell located opposite the lamp in each photometer. The value listed is the one read on the photometer meter with the function switch in the "L" position. The lamp voltage reading is the reading on the photometer meter with the function switch in the "E_L" position.

Table II

Instrument No.	Fast Exhaust (In., H_2O)	Slow Exhaust (In., H_2O)	Lamp Intensity (μa)	Lamp Voltage Reading (volts)
P2-A1	1.65	0.32	19.5	2.85
P6-A2	1.65	0.30	32	2.8
P1-A3	1.7	0.30	13	2.9
P5-A4	1.65	0.30	18.5	3.0
P3-A6	1.6	0.30	26.5	2.8
P4-A5	1.75	0.30	22	2.85

The Flow System

Referring again to Figure 2, if the sample tubes of the photometer should become clogged due to operation in extremely dirty atmosphere or due to the inadvertent injection of moisture in the tubes, it will be necessary to clean them. This can be done by blowing them out with clean air from a squeeze bulb, and if necessary, inserting a nylon fishing line into the sample tube. When using the nylon line, the dilution valve should be set at the X1 position, and the line should be gently inserted into the tube and eased past the dilution valve on down into the chamber. The dilution valve should next be put in the "infinite" position and the line again inserted into the sample tube and eased past the dilution valve. Since the exhaust tube curves, it might not be possible to pass the line all the way through. The remaining part of the by-pass exhaust tube can be probed by removing the rubber tubing from the side of the photometer barrel.

The flow system of each section of the photometer has been balanced by means of the resistance valves to obtain proper dilution action and to maintain constant flow at different dilution settings. Varying total flow should not affect the balance conditions, but varying the total flow in one section will affect the total flow in the other. The easiest method of determining balance of flows in one section of the photometer is by measuring flows at different dilution valve settings. The by-pass resistance valve should be set to provide equal sample flow at X1 dilution and infinite dilution. These points should be precisely determined by observing the peaks of a draft gage connected to the sample tube as the dilution valve is rotated. The flow at an intermediate dilution setting should be set to the same value by means of the dilution resistance valve. If the sample flow is greater in the middle than on the ends, the dilution flow is not great enough, and the dilution resistance valve must be opened. If the faces of a dilution valve are not exactly matched, leakage across the faces at X1 and infinite dilution can occur. This condition is noticeable when sampling high particle concentrations with the dilution valve in the infinite position. Therefore, it is desirable to have the dilution resistance slightly on the low side, so that at infinite dilution any leakage across the valve will be from the dilution line into the by-pass line instead of from the sample line into the tube going to the photometer chamber.

The Lamp

The lamp is operated at 2.8 to 3.0 volts to provide long life, and lamp changing should be required infrequently. Lamp voltage readings vary because of differences in meter calibration and because some lamps require more voltage to produce the desired brightness. When a lamp is replaced, its filament must be accurately located to provide proper sensitivity and uniformity of response of the photometer. To replace the lamp, remove the lamp holder by removing the three thumb nuts at the bottom of the illuminator and unsoldering the lead to the lamp flange. The lamp can then be drawn out after loosening the screws in the lamp holder barrel. The leads to the lamp are soldered onto the bottom contact and onto the flange, and the new lamp should be resoldered in the same manner. After the lamp has been replaced, remove the back of the slow photometer chamber. Remove the plugs from the two high-voltage supplies, and lower the lamp voltage by means of the rheostat in the photometer case. Adjust the lamp so that the light from the filament and the mirror pass through the aperture in the illuminator lens system. Then, with a small piece of paper, observe the image of the lamp filament over the end of the sample tube. The image of the filament should be focused about 1/16 inch beyond the sample tube and on the axis of this tube. The filament image should be perpendicular to the sample stream and located so that it completely covers the stream.

When the image is properly focused in the slow photometer, it should be in focus in the fast photometer also. Next, replace the chamber cover, turn the lamp back up to 2.8 to 3.0 volts, and replace the high-voltage supply sockets. Observe the pulse height and shape when sampling uniform polystyrene particles in the slow section. When sampling 0.55 micron particles, the ratio of signal to peak noise as observed on an oscilloscope should be at least 10:1. If necessary, adjust the lamp position by means of the three thumb nuts to obtain optimum uniformity and sensitivity. There is no method of adjusting the second image with respect to the first; therefore, a compromise of the best wave shape in each section of the photometer must be made.

Phototube

If a phototube becomes noisy or loses sensitivity, it will require replacement. This can be done by removing the potted resistance string and removing the four screws and the clamp on the bottom of the phototube housing. When a new tube is installed, replace the clamp and O-ring on its base, but do not tighten the screws. Replace the resistance string, turn on the instrument, and observe pulses from polystyrene particles while twisting the phototube to obtain maximum sensitivity. Then tighten the clamp. The high-voltage supplies for the phototubes have been modified as shown in Drawing 1360-B-39, reproduced in the Appendix.

Electrical and Electronic Circuits

Wiring diagrams of the photometer and analyzer are shown on Drawings 1360-D-31, D-32, D-33, and D-34, reproduced in the Appendix. Circuit diagrams are shown on the following drawings reproduced in the Appendix: 1360-B-17, B-18, B-20, B-21, B-22, B-29, and B-42. The layouts of circuit board components, with test points noted, are shown in photographs in the Appendix.

The +12 and -22 volt power supplies are potted by the manufacturer and cannot be repaired. The inverter has a potted transformer, but the other components are replaceable. The circuit of the inverter is shown in Drawing 1360-B-45, reproduced in the Appendix.

The instruments are designed to operate from 6.3 volt lead-acid batteries, but can be used with silver-zinc cells which have a fully charged output of 7.2 volts for four cells in series. The instruments will operate down to about 5.5 volts input using the short cable between analyzer and photometer. The voltage regulators, which have a nominal output of 5.0 volts, have been set to 4.8 volts so that any of the photometers can operate from the 155-foot cable. The lower limit of input voltage with the 155-foot cable is about 5.8 volts. The current required for each instrument is about 4.75 amps. Additional current is required for the recorders.

PARTS LIST

The mechanical parts are called out on the individual mechanical drawings. The following is a list of electrical parts used.

Parts List for One Complete Set of Circuit Boards

Transistors:

Type	Manufacturer	No. Required
2N508	G. E.	124
2N169A	G. E.	68
2N338	G. E.	10
2N1012	Gen. Transistor	6
2N1193	Motorola	7
2N456A	T. I.	1
2N753	T. I.	16
2N1131	T. I.	16

Diodes:

1N3253	RCA	36
DR385	Radio Receptor	28
1N720A	Zener, Hoffman	2

Capacitors:

Size	Type	
0.5 μf	Hopkins, Metallized Paper	19
0.2 μf	Hopkins, Metallized Paper	18
.005μf	Hopkins, Metallized Paper	2
.01 μf	Hopkins, Metallized Paper	12
.1 μf	Hopkins, Metallized Paper	2
.5 μf	Hopkins, Metallized Paper	2
47 μf	Solid Tantalum, 35 V	16
47 μf	Solid Tantalum, 10 V	14
33 μf	Solid Tantalum, 35 V	1

Capacitors (Continued)

Size	Type	No. Required
.002μf	Aerovox Paper	2
Selected value each board	Ceramic Disc.	4
660mmf	Ceramic Disc.	1
39mmf	Ceramic Disc.	2
25mmf	Ceramic Disc.	3
30mmf	Ceramic Disc.	1

Potentiometers:

1K	Bourns, Type 3367P	3
5K	Bourns, Type 3367P	12
10K	Bourns, Type 3367P	4
20K	Bourns, Type 3367P	2
100 ohms	Bourns, Type 3367P	8

Chokes:

100μh	2 ohms, Miller No. 4632	1

Thermistors:

1K	Fenwal No. KA31L1	4

Transistor Sockets:

Type	Manufacturer	
RA4	Vector	216

Plugs and Sockets (boards):

DEP15 P-96	Armel	22 plugs
DEP15-S3	Armel	22 sockets

Precision Resistors:

Size	Type	No. Required
1 K	All $\frac{1}{4}$ w, 1% Tol.	8
3.57K		8
10 K		47
12.1 K		8
26.7 K		8
47.5 K		8
49.9 K		8
56.2 K		8
68.1 K		20
300 ohms		10
1.2 K		10
2 K		11
15 K		12
20 K		10
5 K		2
50 K		2

Resistors:

470 ohms	All $\frac{1}{4}$ w, 1% Tol.	1
680 ohms		15
1.5 K		1
3.9 K		3
7 K		1
10 K		67
22 K		16
100 ohms		15
220 ohms		4
270 ohms		4
120 K		4
33 K		7
100 K		18
330 K		2
390 K		4
470 K		4
1 K		7
1 M		16

Resistors (Continued)

Size	Type	No. Required
1.8M	All $\frac{1}{4}$ w, 1% Tol.	2
27 K		1
4.7K		14
5.6K		10
91 K		10
220 K		12
470 K		2
47 K		1
12 K		6
3 K		6
5 K		4
2 ohms		1

Electrical Parts List for Analyzer

Description	No. Required
Power Switch, S.P.S.T. Cutler-Hammer, No. 8821-K6	1
Power Indicator Lamp, Dialco No. 810-B-431	1
Lamp Bulb, 6-8V, .15 amp, Chicago Min. Lamp No. 47	1
Range Change Switches, miniature, 5 amp, S.P.D.T., Torbal No. SP-6, short handle	10
Transformer, Stancor No. P-3064	1
Fuse, Littlefuse, No. 3AG 10A	2
Inverter, 6 volt d-c to 115 volt 400 cycle a-c, Sorensen Model DQI 6/115-0.26	1
Power supply, 115 VAC to 22 volt, d-c, Technipower, Inc., Type M-21.2-0.200AI	1
Power supply, 115 VAC to 12 volt, d-c, Technipower, Inc., Type M-21.2-0.200AI	1
Buffer Relay, Advance Series PG 2C	1
Power Supply Cable Connector, MS-3102R-16S-5P	1
Remote Control Cable Connector, MS-3102R-16S-4P	1
Photometer Cable Connector, MS-3102R-20-27S	1
Recorder Cable Connector, MS-3102R-20-29S	1

Electrical Parts List for Analyzer (Continued)

Description	No. Required
Calibrate Switch, miniature, 5 amp, ball end, D. P. D. T., Torbal	2
Resistor, 2.2K $\frac{1}{4}$ watt, 10% tol.	2
Potentiometer, 0.093" Mandrel, 14" long, wound with .00225" wire, 200 turns inch, 5000 ohms, total Spectrol Electronics	4

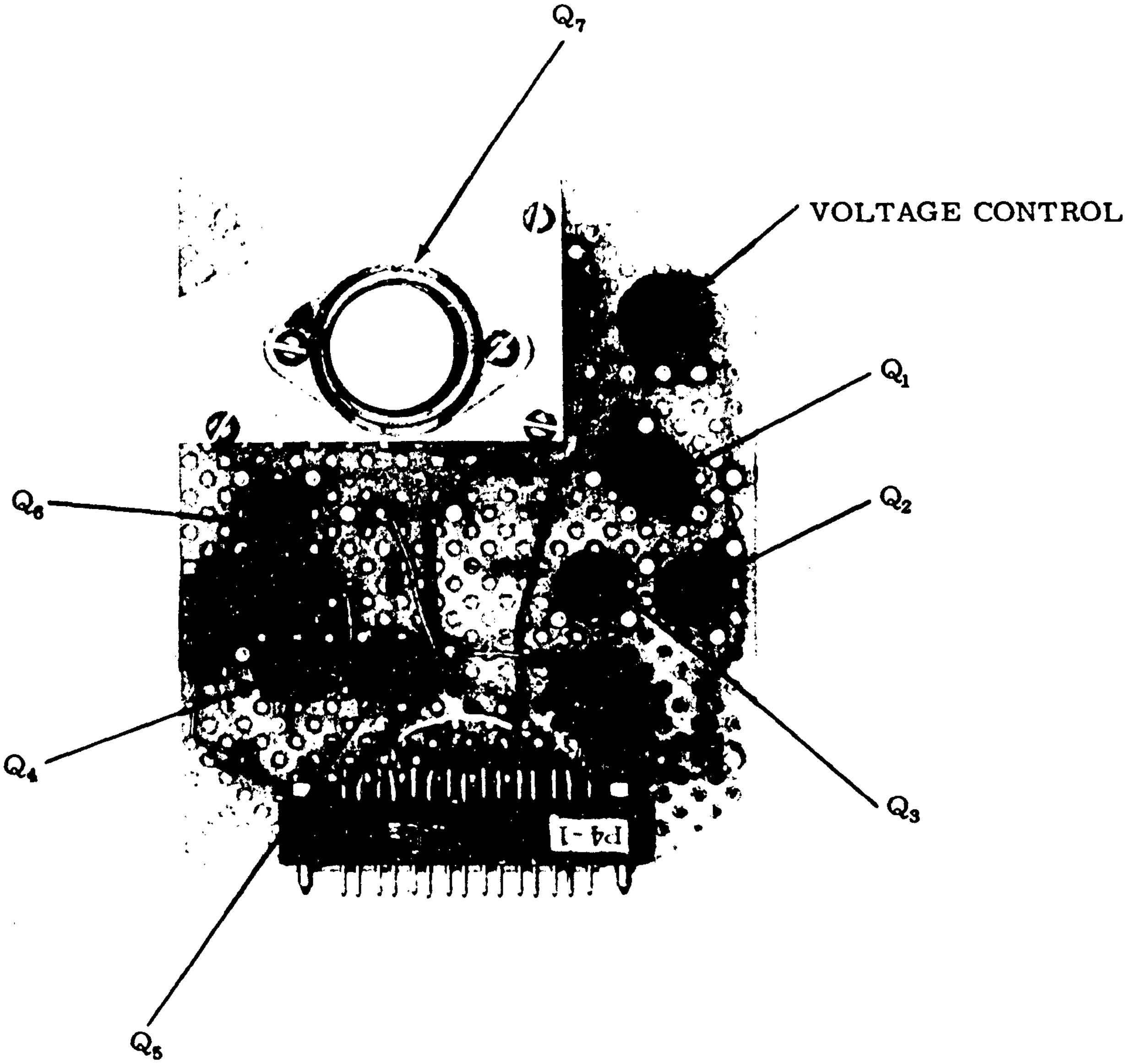
Electrical Parts List for Photometer

Description	No. Required
Connector, Amphenol, Type MS-3102A-20-27S	1
Switch, Centralab, 8 pole, 4 position, non-shorting, Type P. A.	1
Motor, Globe Type 3A1409, 6 volts, 5000 RPM, with R. I. filter, Type 40-S-252	1
Meter, Edge Reading, 0-100 microamperes, Simpson, Type 1502	1
Potentiometer, 5 ohm, 2 watt, Clarostat, Type 43 C 2-5	1
High-voltage supply, Components Corp. Model 73, modified	2
Photomultiplier Tube, RCA, Type 1P21	2
Phototube Socket, Amphenol 11-pin, Type 78-RS11T	2
High-voltage supply socket, Amphenol, 8-pin	2
Photometer Lamp, Chicago Min. Lamp No. CM 8-903, 3.5 volt, .63 amp, 1.35 C. P.	1
Silicon Resistor, 1K, $\frac{1}{4}$ watt, 10% tol.	1
Silicon Solar Cell, Hoffman, Type 55C	1
Resistor, 220K, $\frac{1}{4}$ watt, 10% tol.	2
Resistor, 2.2K, $\frac{1}{4}$ watt, 10% tol.	2
Resistor, 2M, $\frac{1}{8}$ watt, 1% tol.	20
Capacitor, .01μf, 1000 volt, Ceramic Disc.	2
Dilution Potentiometer, 1K, IRC Type 751-3003-1	1
Potentiometer, 2K, Bournes, Type 271-1-202	1
Capcitor, .0075μf, 1000 volt, Ceramic Disc.	2

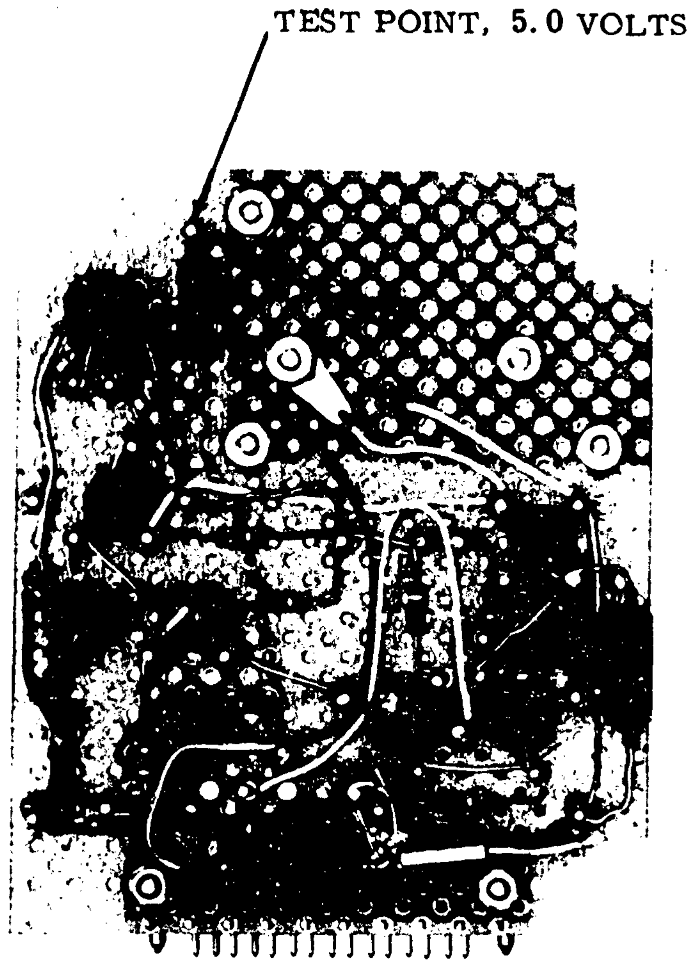
RECOMMENDED SPARE PARTS FOR SIX MULTI-CHANNEL PARTICLE SIZE ANALYZERS DEVELOPED FOR THE U.S. CHEMICAL CORPS UNDER CONTRACT NO. DA-18-064-CML-2793

Description	Quantity
Circuit board	21
Technipower supply	4
Inverter	1
Meter	1
Relay	1
Battery clamp	6
Pilot lamp	10
Filter	4
Dryer	2
Power switch	1
Torbal SP switch	2
Phototube, 1P21	2
Board connector, male	10
Board connector, female	2
HV rectifier	2
HV corona tube	2
Resistance element	2
Lamp, aged	6
Fuse	12
Spare AN connector	3
Plastic sheet for return packing	14
Roll carton sealing tape	1
Transistor, 2N508	10
Transistor, 2N753	8
Transistor, 2N1131	4
Transistor, 2N1193	6
Transistor, 2N169A	6
Transistor, 2N338	4
Transistor, 2N1012	6
Transistor, 2N456A	2

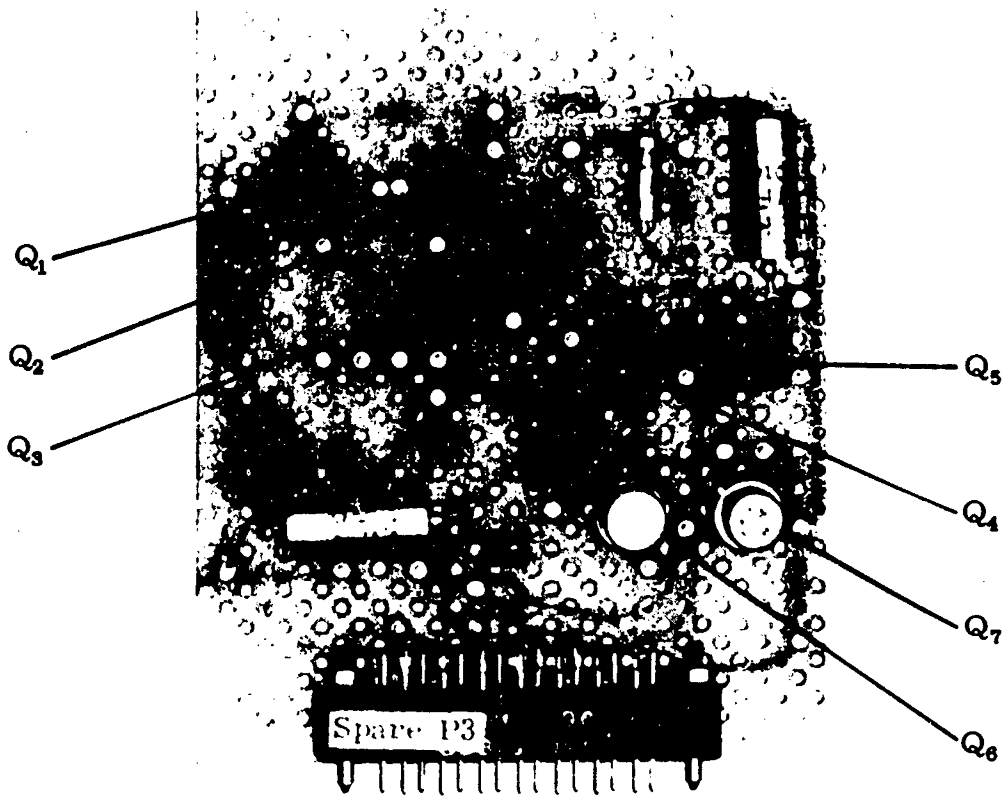
APPENDIX



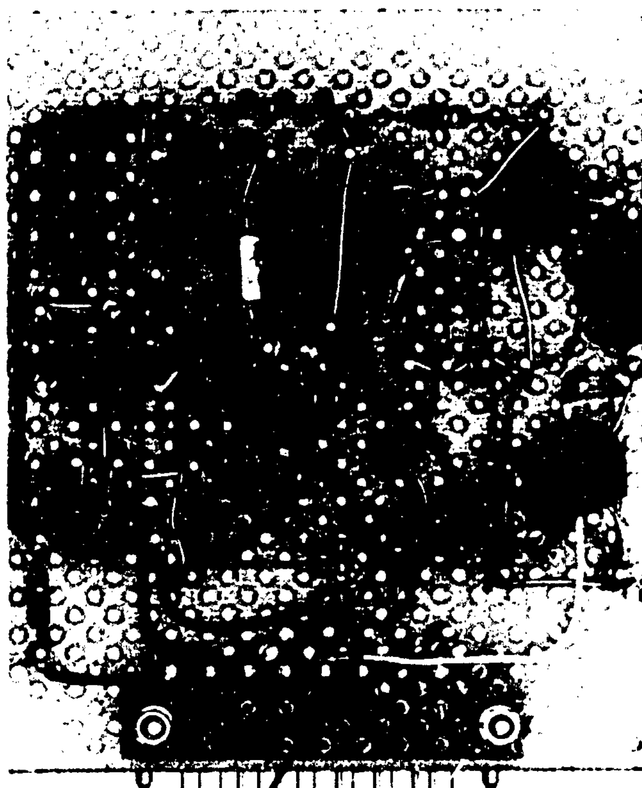
VOLTAGE REGULATOR BOARD
(FRONT)



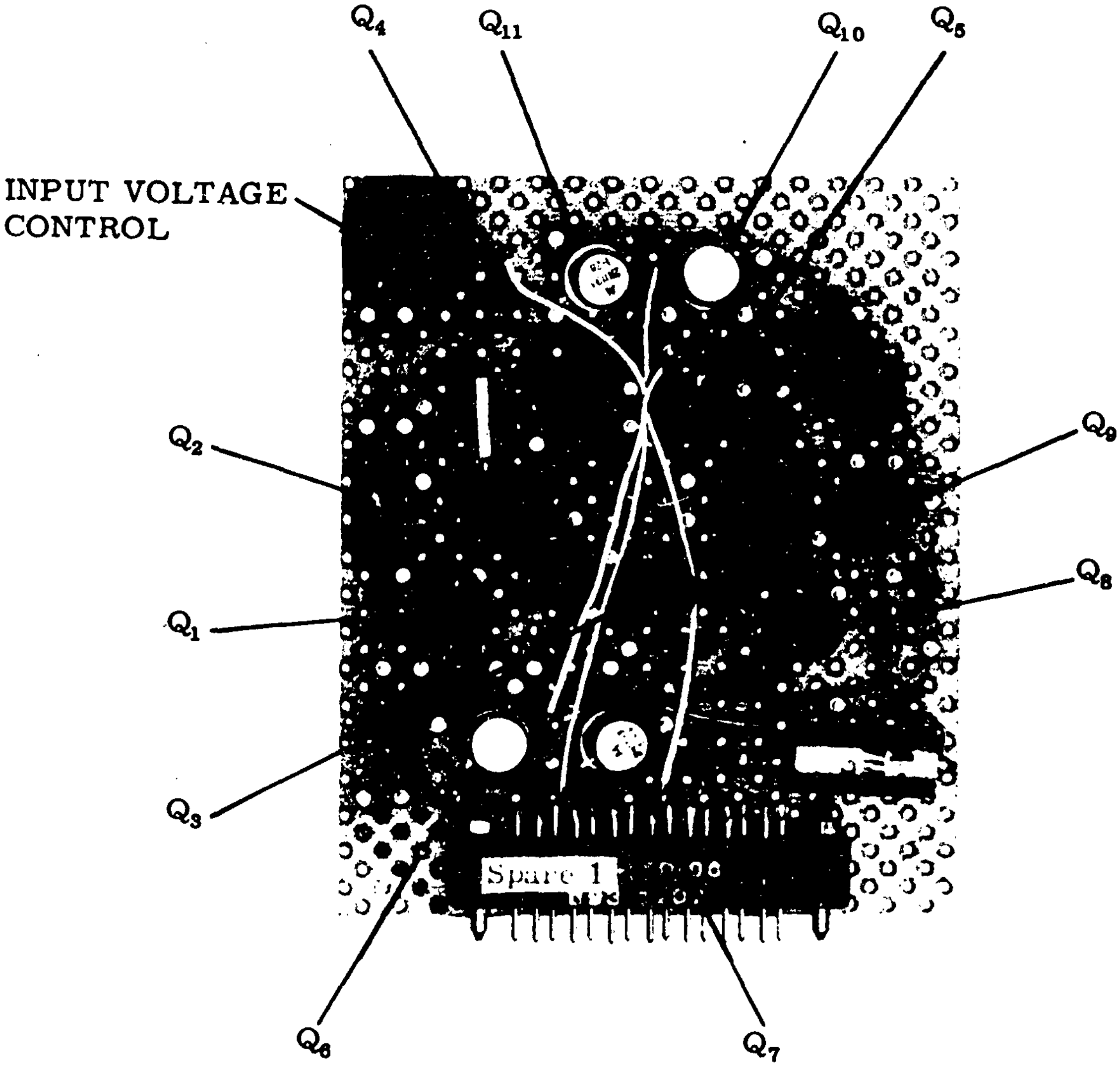
VOLTAGE REGULATOR BOARD
(REAR)



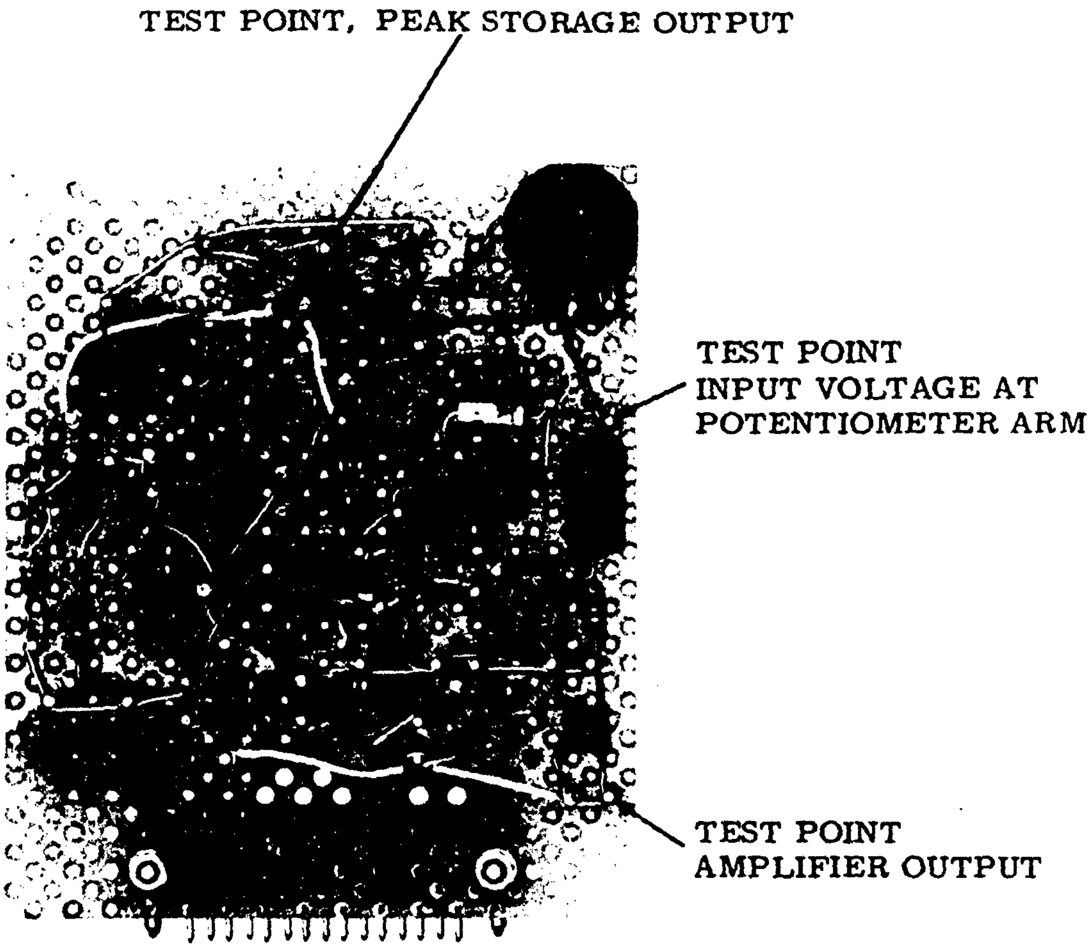
PRE-AMPLIFIER BOARD
(FRONT)



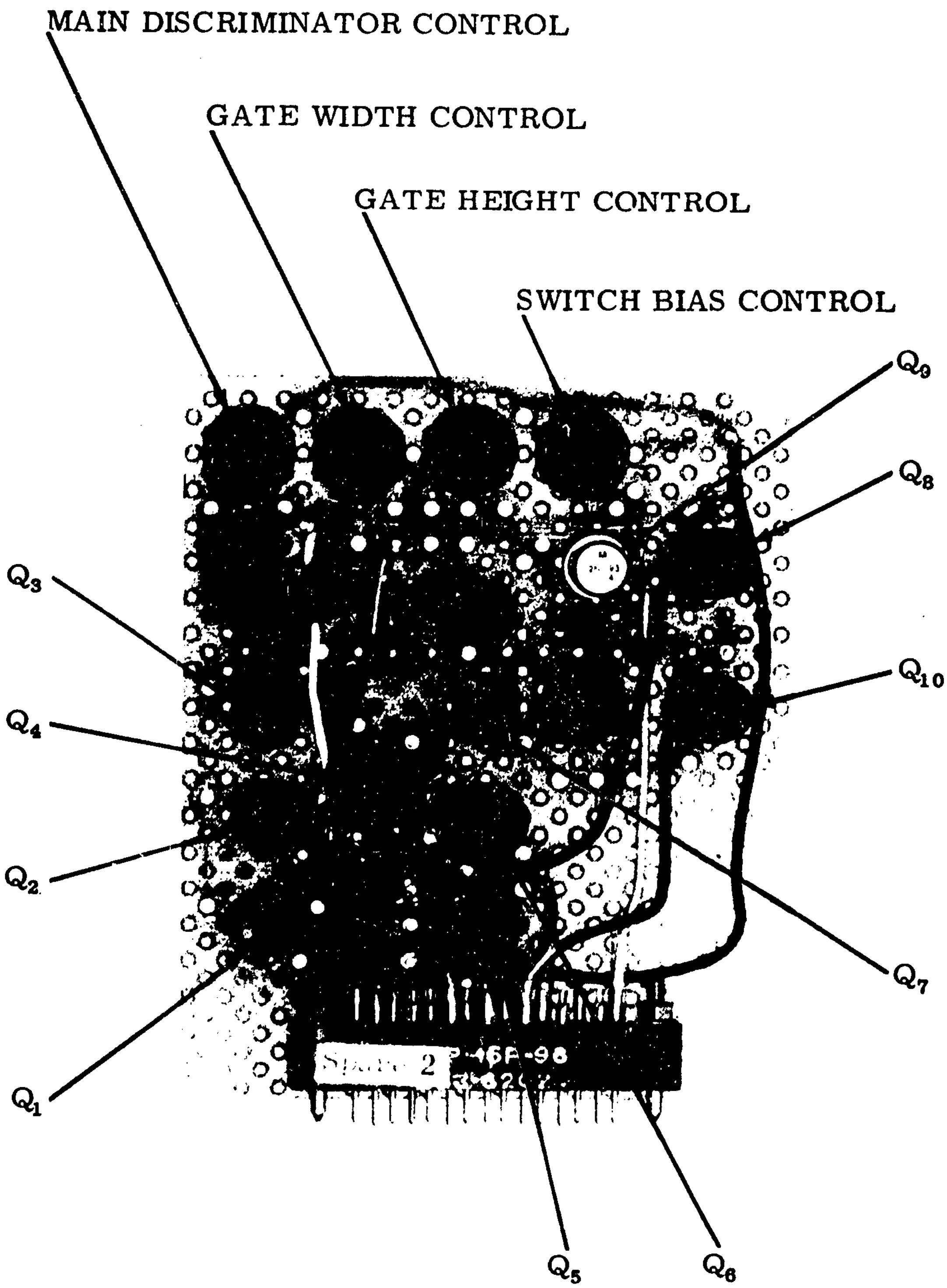
PRE-AMPLIFIER BOARD
(REAR)



AMPLIFIER AND PEAK STORAGE BOARD
(FRONT)

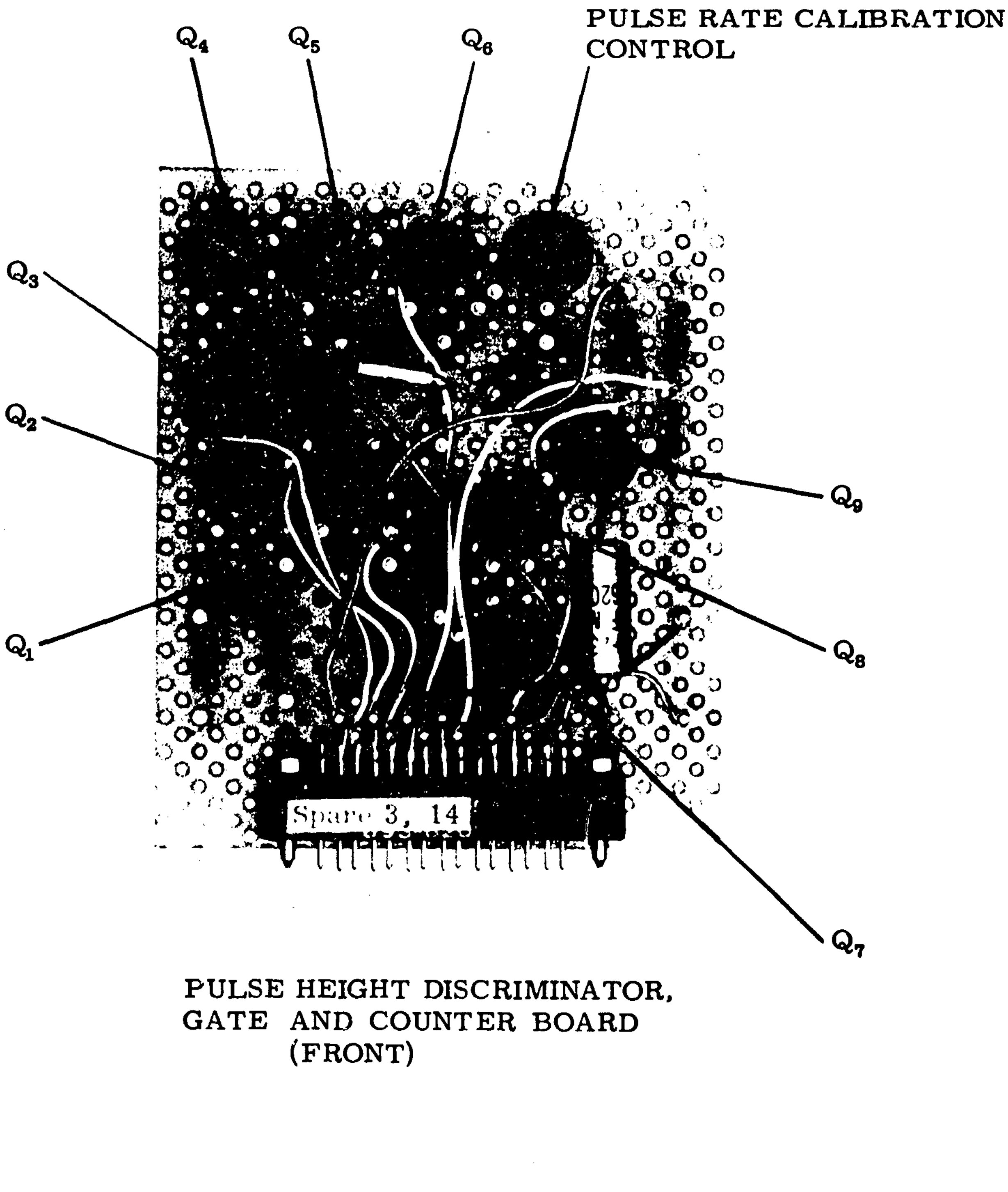


AMPLIFIER AND PEAK STORAGE BOARD
(REAR)

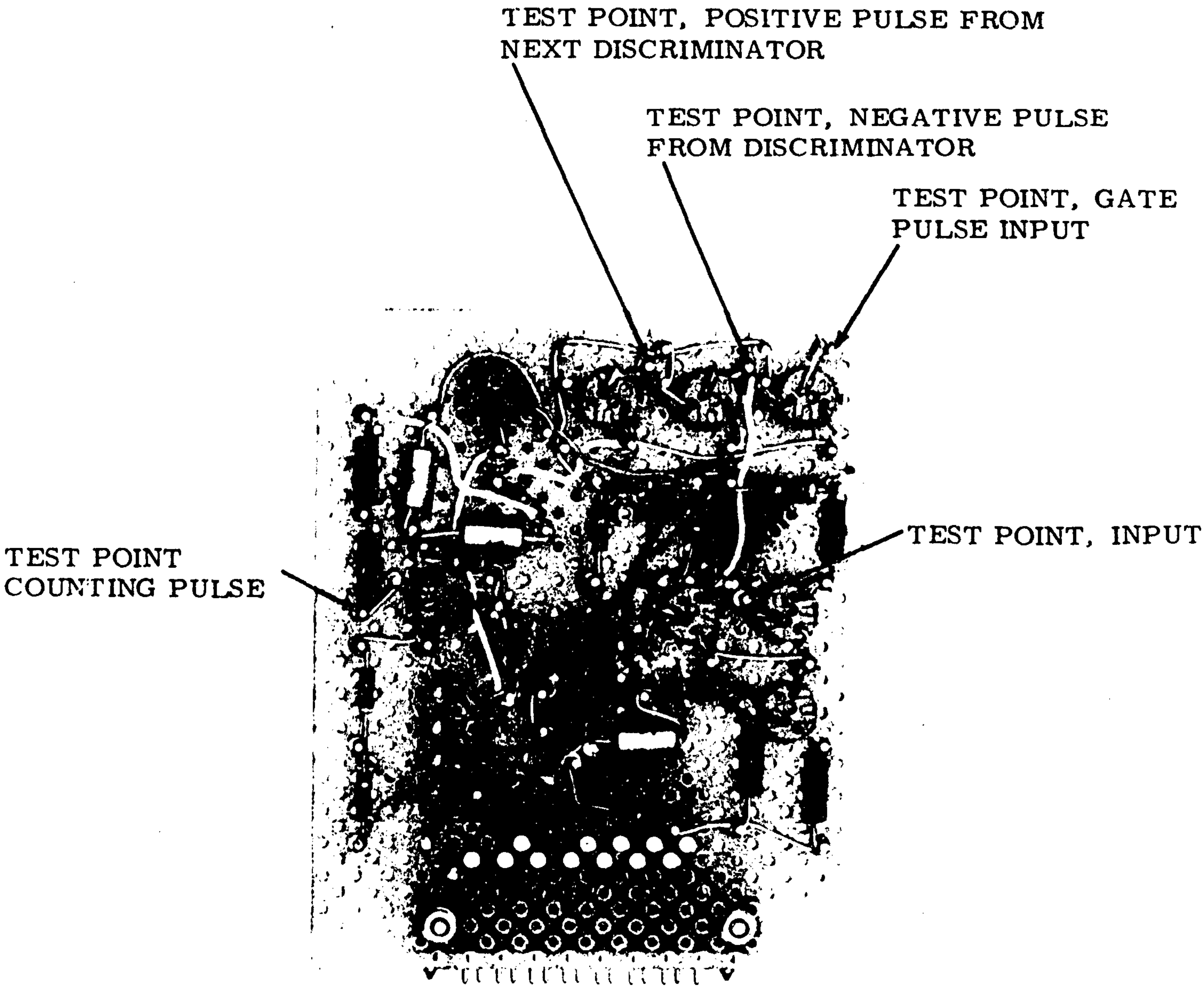


MAIN DISCRIMINATOR AND
GATE GENERATOR BOARD
(FRONT)

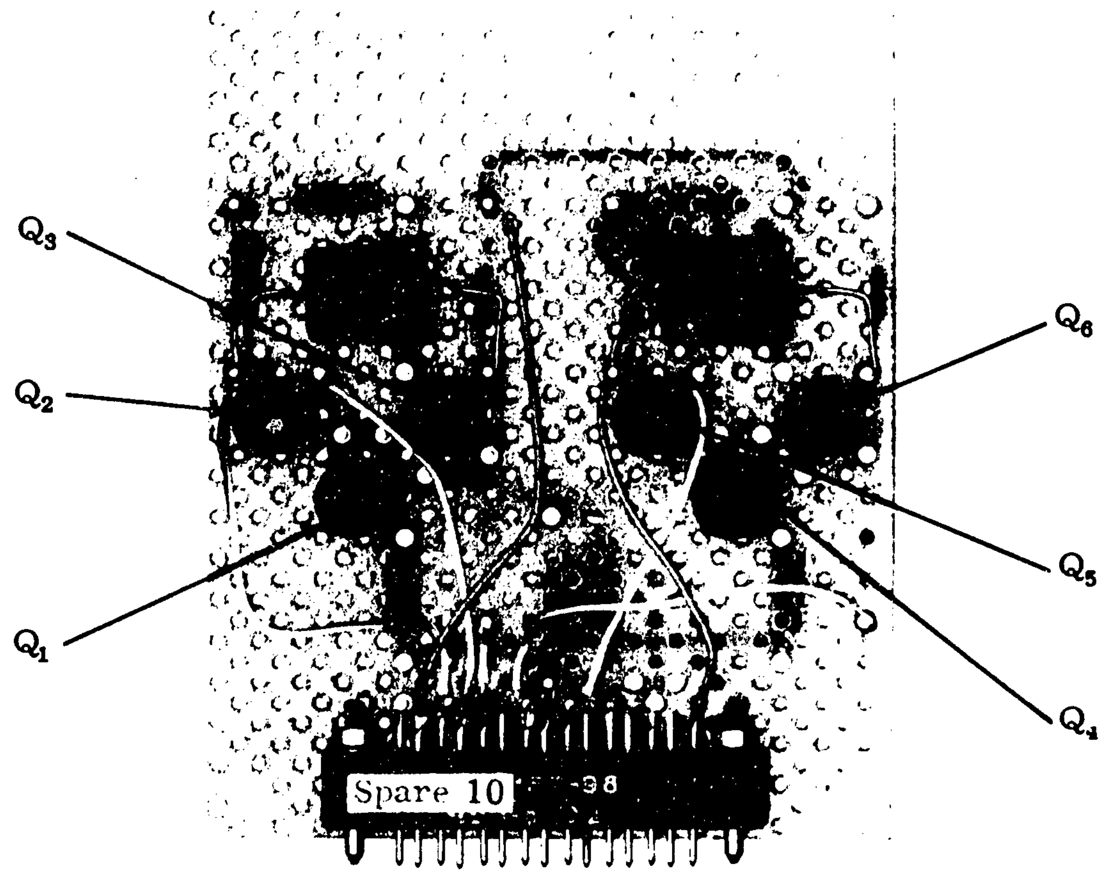
MAIN DISCRIMINATOR AND
GATE GENERATOR BOARD
(REAR)



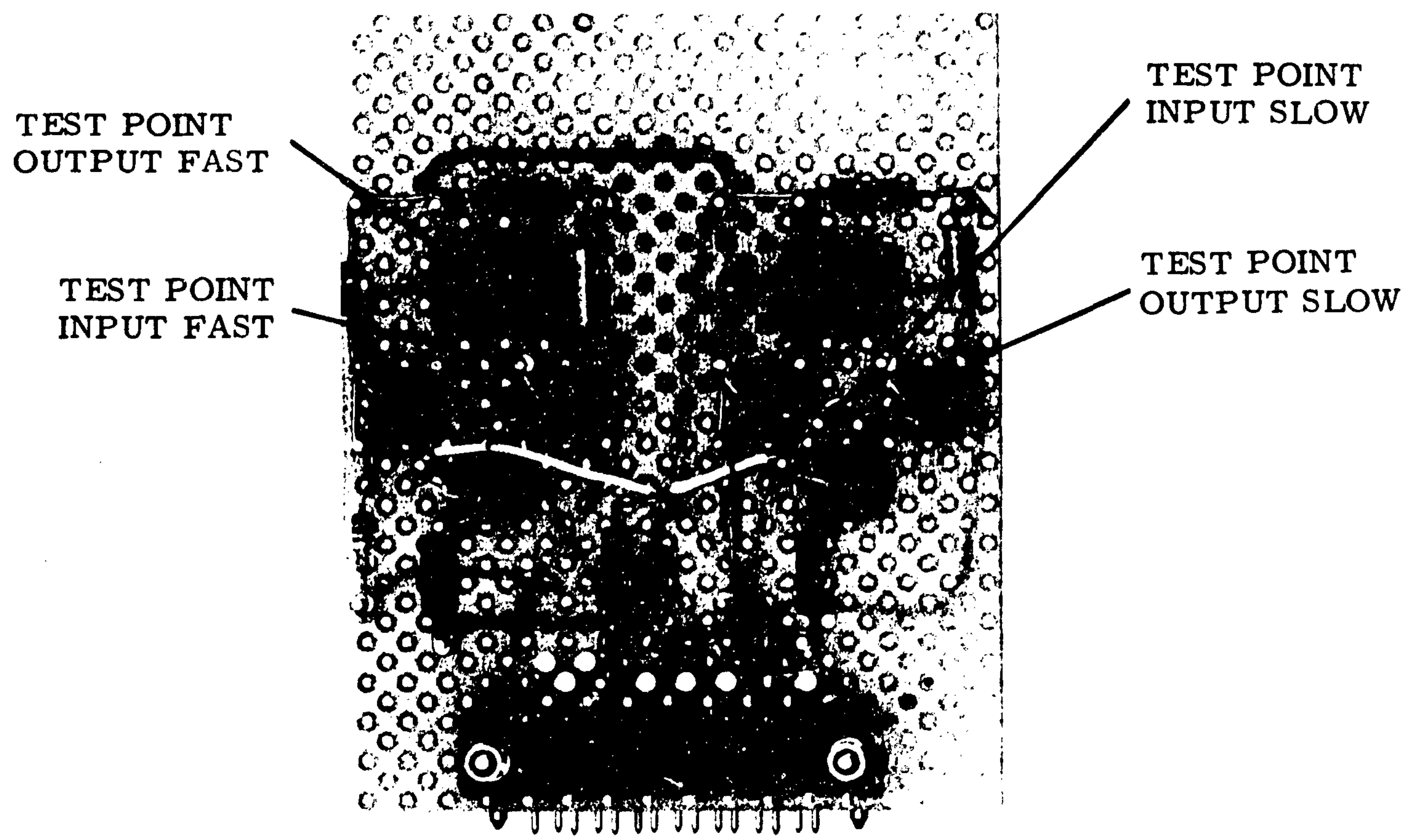
PULSE HEIGHT DISCRIMINATOR,
GATE AND COUNTER BOARD
(FRONT)



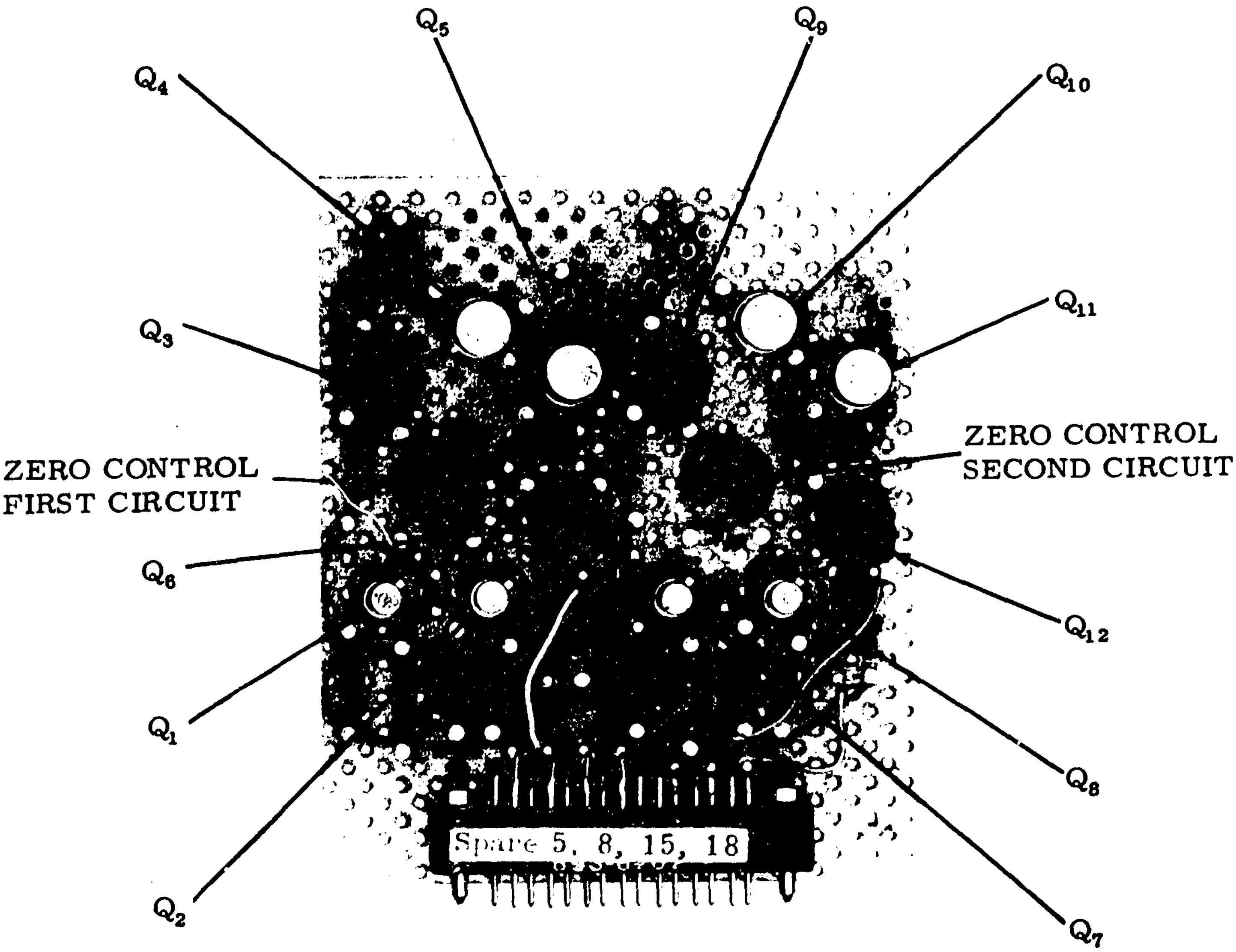
PULSE HEIGHT DISCRIMINATOR,
GATE AND COUNTER BOARD
(REAR)



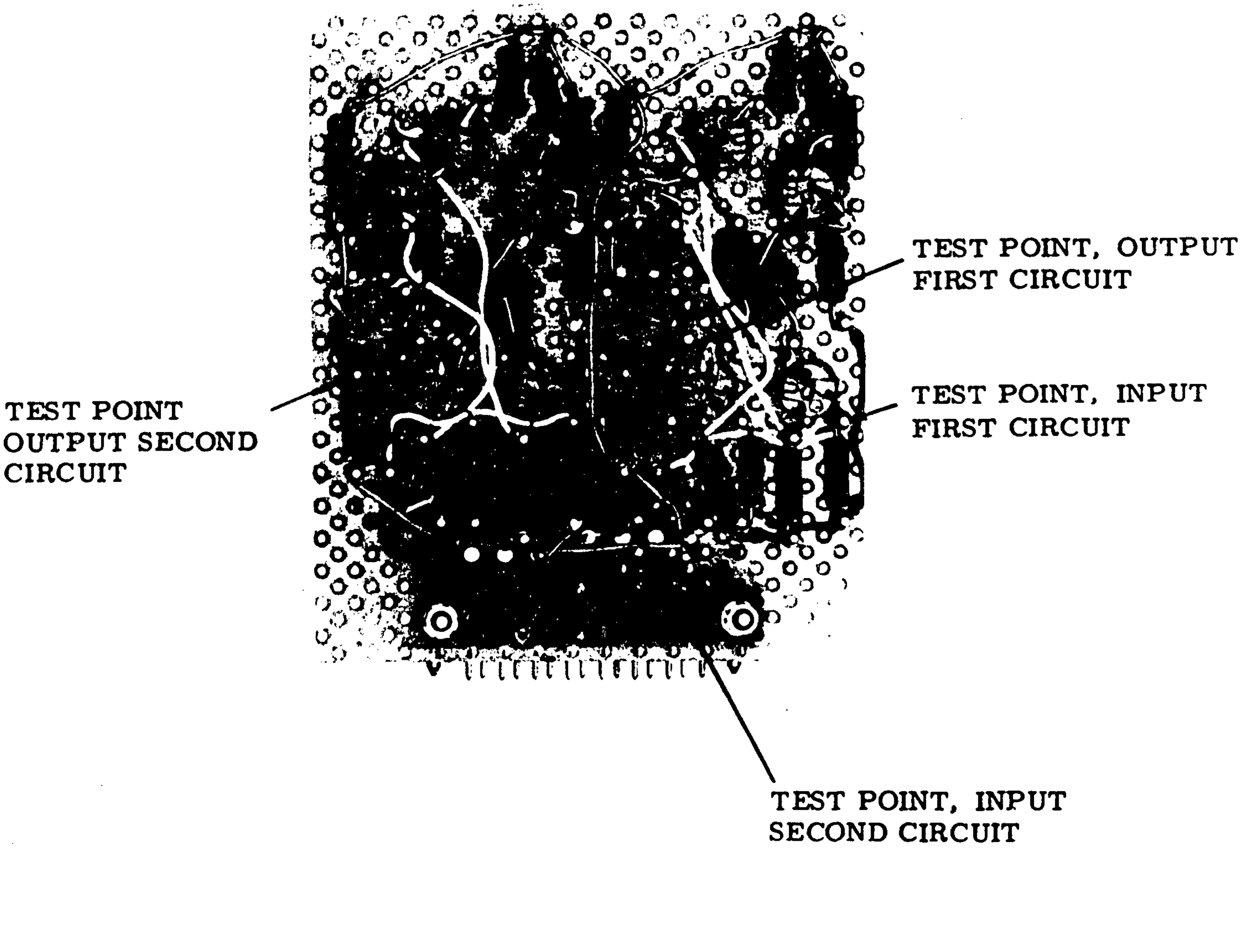
PULSE HEIGHT DISCRIMINATOR,
GATE CLOSING BOARD
(FRONT)



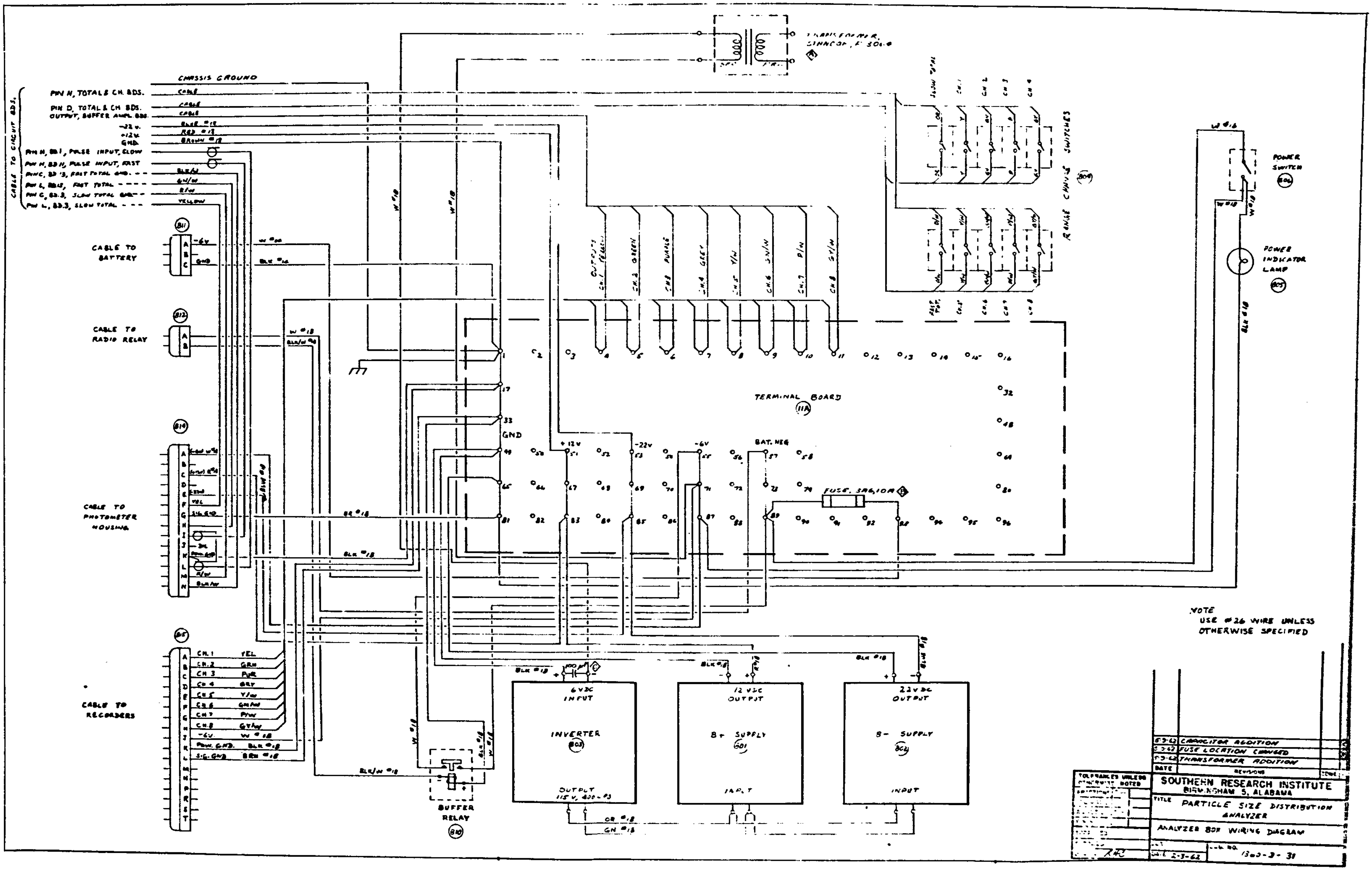
PULSE HEIGHT DISCRIMINATOR,
GATE CLOSING BOARD
(REAR)



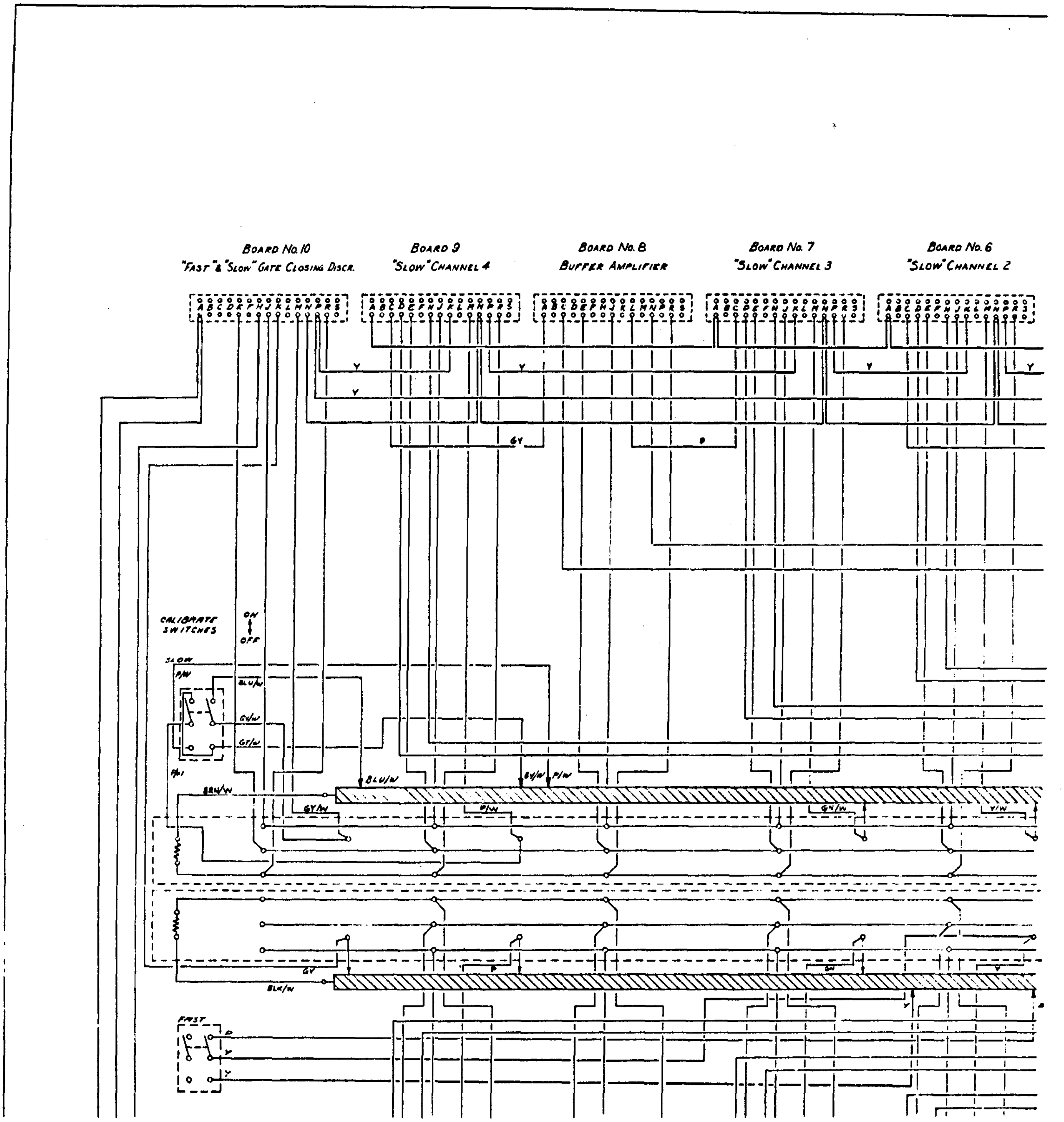
BUFFER AMPLIFIER BOARD
(FRONT)

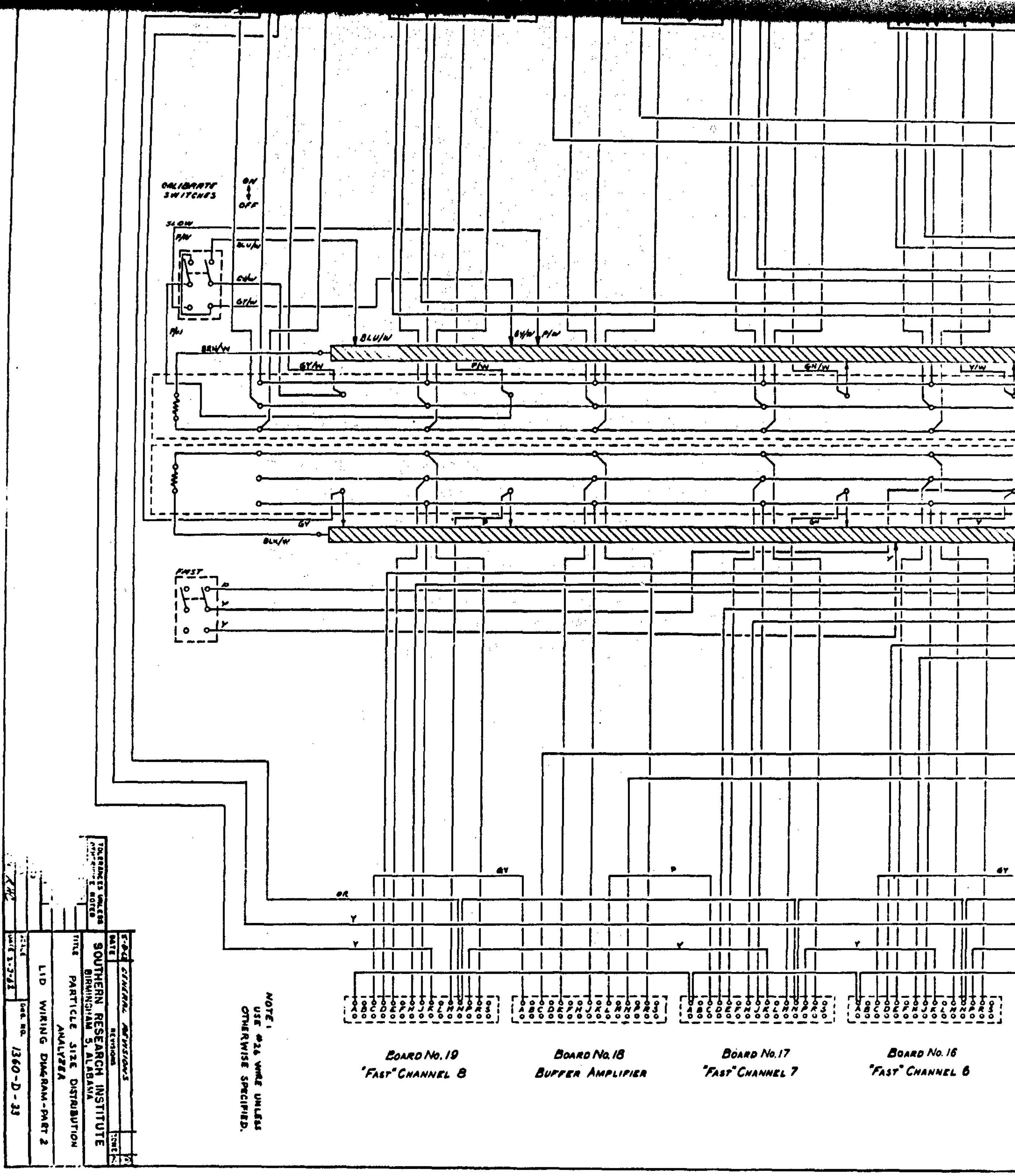


BUFFER AMPLIFIER BOARD
(REAR)


CHASSIS GROUND
CABLE TO CIRCUIT BDS.
PIN N, TOTAL & CH. BDS.
PIN D, TOTAL & CH. BDS. OUTPUT, BUFFER AMPL. BDS.
-22 v.
+12 v.
GND.
PIN H, BD.1, PULSE INPUT, SLOW
PIN H, BD.1/1, PULSE INPUT, FAST
YELLOW
CABLE TO BATTERY
-6V
GND
CABLE TO RADIO RELAY
CABLE TO PHOTOMETER HOUSING
CABLE TO RECORDERS
CH. 1 YEL
CH. 2 GRN
CH. 3 PUR
CH. 4 GRY
CH. 8
-6V
POW. GND.
SIG. GND.
TRANSFORMER, SINNCOR, F 30
RANGE CHANGE SWITCHES
OUTPUTS
CH. 2 GREEN
CH. 3 PURPLE
CH. 4 GREY
TERMINAL BOARD
GND
+12V
-22V
-6V
BAT. NEG
FUSE
POWER SWITCH
POWER INDICATOR LAMP
NOTE
USE #26 WIRE UNLESS OTHERWISE SPECIFIED
6VDC INPUT
INVERTER
OUTPUT 115 V, 400 ~
12 VDC OUTPUT
B+ SUPPLY
INPUT
22 V DC OUTPUT
B- SUPPLY
INPUT
BUFFER RELAY
CAPACITOR ADDITION
FUSE LOCATION CHANGED
TRANSFORMER ADDITION
DATE
REVISIONS
SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM 5, ALABAMA
TITLE
PARTICLE SIZE DISTRIBUTION ANALYZER
ANALYZER BOX WIRING DIAGRAM
1303-3-31

2f A

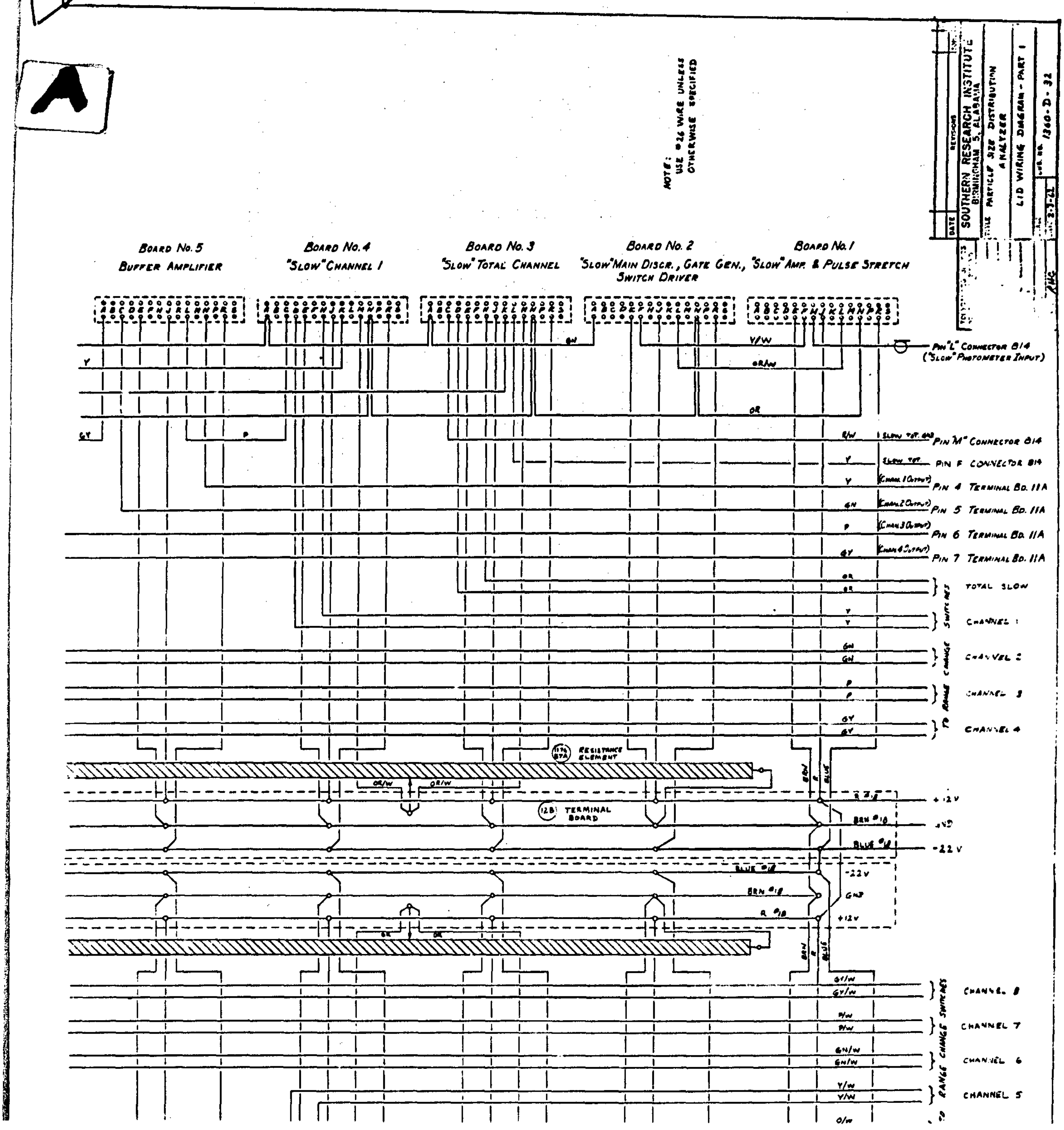

BOARD No. 10
"FAST" & "SLOW" GATE CLOSING DISCR.
BOARD 9
"SLOW" CHANNEL 4
BOARD No. 8
BUFFER AMPLIFIER
BOARD No. 7
"SLOW" CHANNEL 3
BOARD No. 6
"SLOW" CHANNEL 2
CALIBRATE SWITCHES
ON
OFF
SLOW
FAST
BLU/W
GY/W
P/W
BRN/W
BLK/W
GN/W
Y/W


CALIBRATE SWITCHES
ON
OFF
SLOW
FAST
BLU/W
GY/W
BRN/W
P/W
GN/W
Y/W
GY
BLK/W
OR
Y
P
NOTE: USE #26 WIRE UNLESS OTHERWISE SPECIFIED.
BOARD No. 19
"FAST" CHANNEL 8
BOARD No. 18
BUFFER AMPLIFIER
BOARD No. 17
"FAST" CHANNEL 7
BOARD No. 16
"FAST" CHANNEL 6
TOLERANCES UNLESS OTHERWISE NOTED
GENERAL REVISIONS
REVISIONS
SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM 5, ALABAMA
TITLE
PARTICLE SIZE DISTRIBUTION ANALYZER
LID WIRING DIAGRAM-PART 2
DWG. NO.
1360-D-33

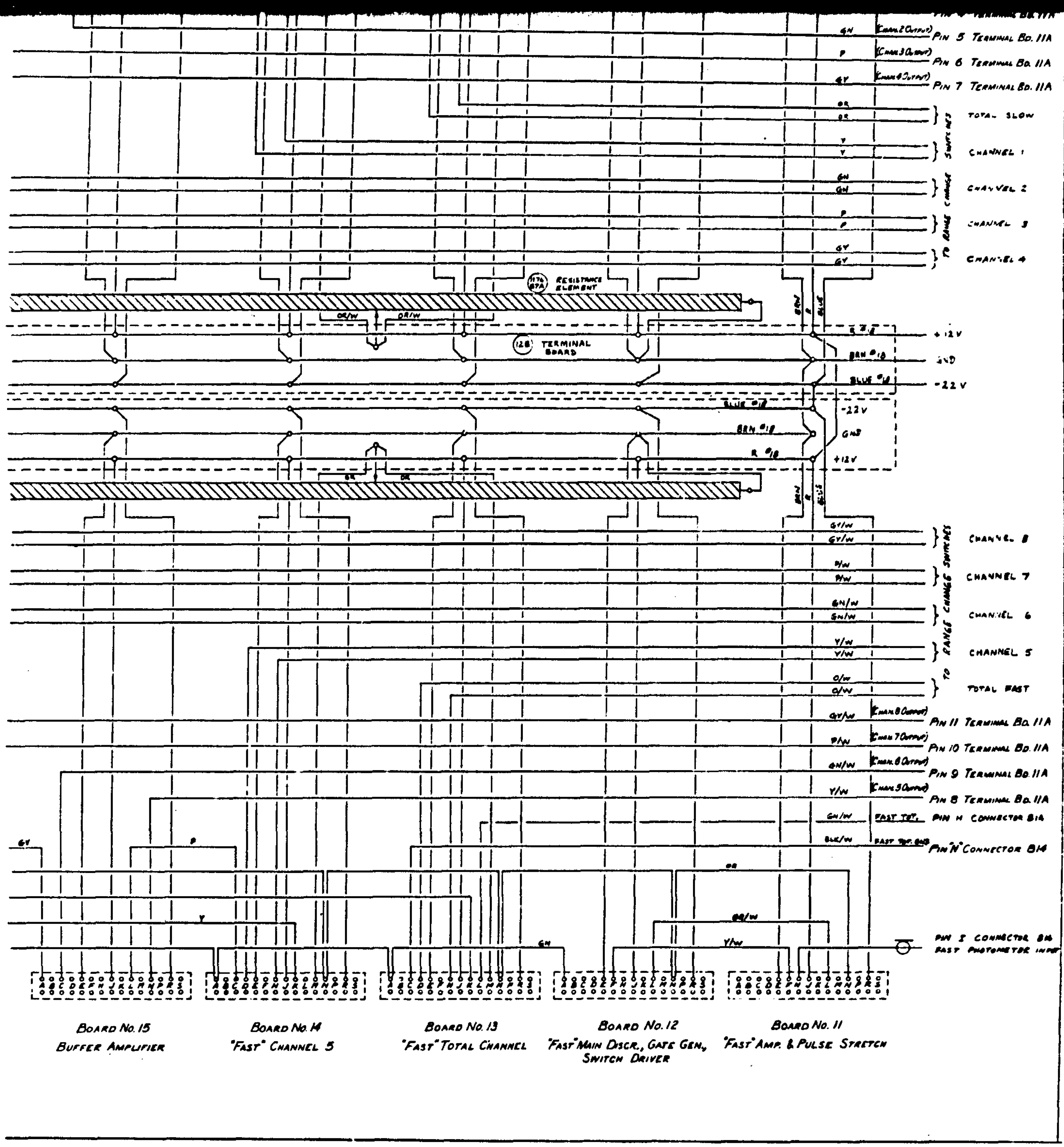
bottom

2

A

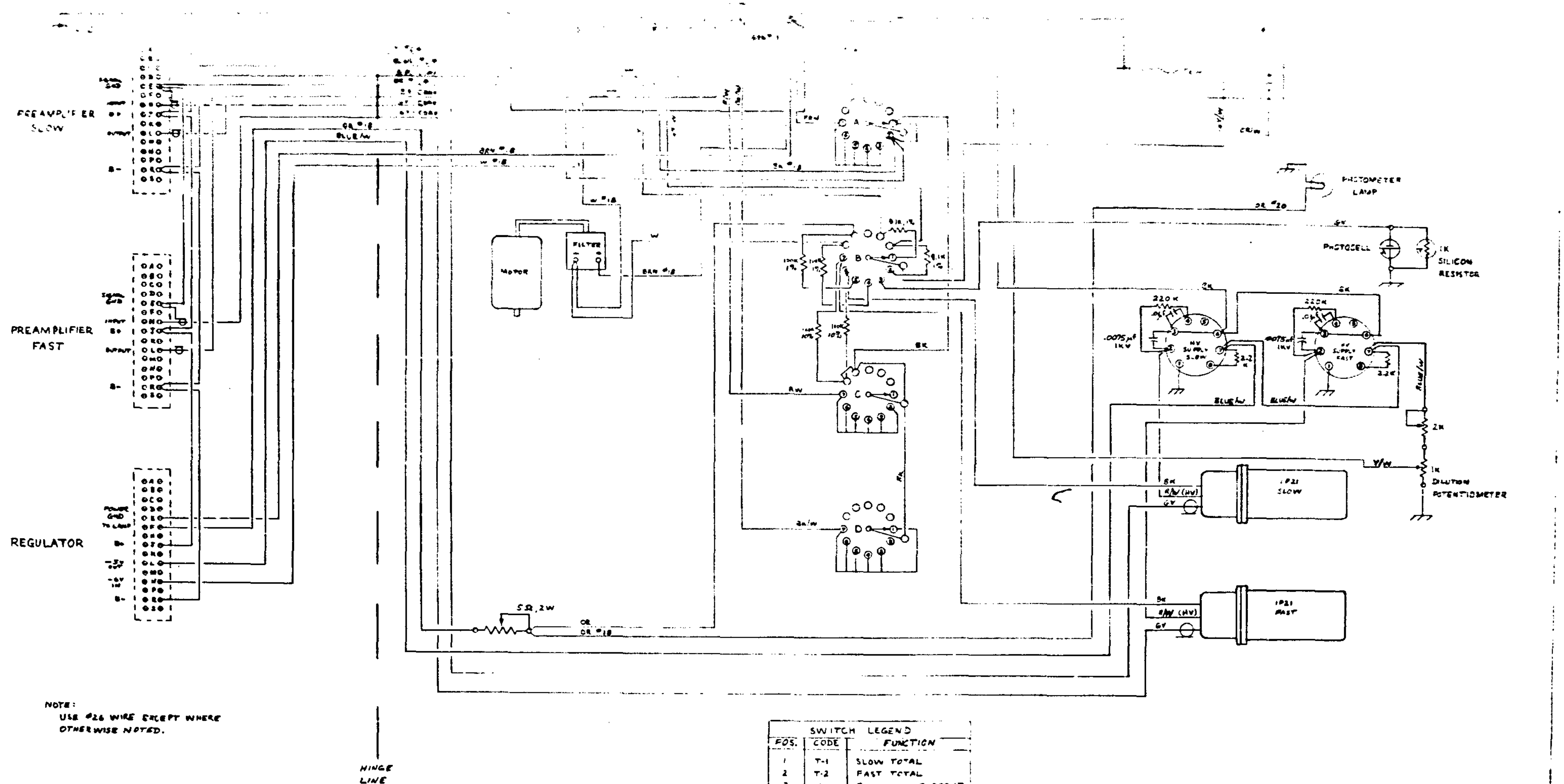


NOTE: USE #26 WIRE UNLESS OTHERWISE SPECIFIED
SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM 5, ALABAMA
TITLE PARTICLE SIZE DISTRIBUTION ANALYZER
LID WIRING DIAGRAM - PART 1
DWG. NO. 1360-D-32
BOARD No. 5 BUFFER AMPLIFIER
BOARD No. 4 "SLOW" CHANNEL 1
BOARD No. 3 "SLOW" TOTAL CHANNEL
BOARD No. 2 "SLOW" MAIN DISCR., GATE GEN., SWITCH DRIVER
BOARD No. 1 "SLOW" AMP. & PULSE STRETCH
PIN "L" CONNECTOR 814 ("SLOW" PHOTOMETER INPUT)
PIN "M" CONNECTOR 814
PIN F CONNECTOR 814
PIN 4 TERMINAL BD. 11A
PIN 5 TERMINAL BD. 11A
PIN 6 TERMINAL BD. 11A
PIN 7 TERMINAL BD. 11A
TOTAL SLOW
CHANNEL 1
CHANNEL 2
CHANNEL 3
CHANNEL 4
TO RANGE CHANGE SWITCHES
RESISTANCE ELEMENT
TERMINAL BOARD
+12 V
GND
-22 V
CHANNEL 8
CHANNEL 7
CHANNEL 6
CHANNEL 5



Pin 5 Terminal Bd. 11A
Pin 6 Terminal Bd. 11A
Pin 7 Terminal Bd. 11A
Total Slow
Channel 1
Channel 2
Channel 3
Channel 4
To Range Change Switches
Resistance Element
Terminal Board
+12V
GND
-22V
Channel 8
Channel 7
Channel 6
Channel 5
Total Fast
Pin 11 Terminal Bd. 11A
Pin 10 Terminal Bd. 11A
Pin 9 Terminal Bd. 11A
Pin 8 Terminal Bd. 11A
Pin H Connector B14
Pin "N" Connector B14
Pin I Connector B14
Fast Photometer Input
Board No. 15
Buffer Amplifier
Board No. 14
"Fast" Channel 5
Board No. 13
"Fast" Total Channel
Board No. 12
"Fast" Main Discr., Gate Gen., Switch Driver
Board No. 11
"Fast" Amp. & Pulse Stretch

bottom



NOTE:
USE #26 WIRE EXCEPT WHERE OTHERWISE NOTED.

SWITCH	LEGEND	
POS.	CODE	FUNCTION
1	T-1	SLOW TOTAL
2	T-2	FAST TOTAL
3	L	PHOTOCELL CURRENT
4	A	BATTERY VOLTAGE
5	E_L	LAMP VOLTAGE
6	H-1	SLOW HV SUPPLY
7	H2	FAST HV SUPPLY

GENERAL REVISIONS

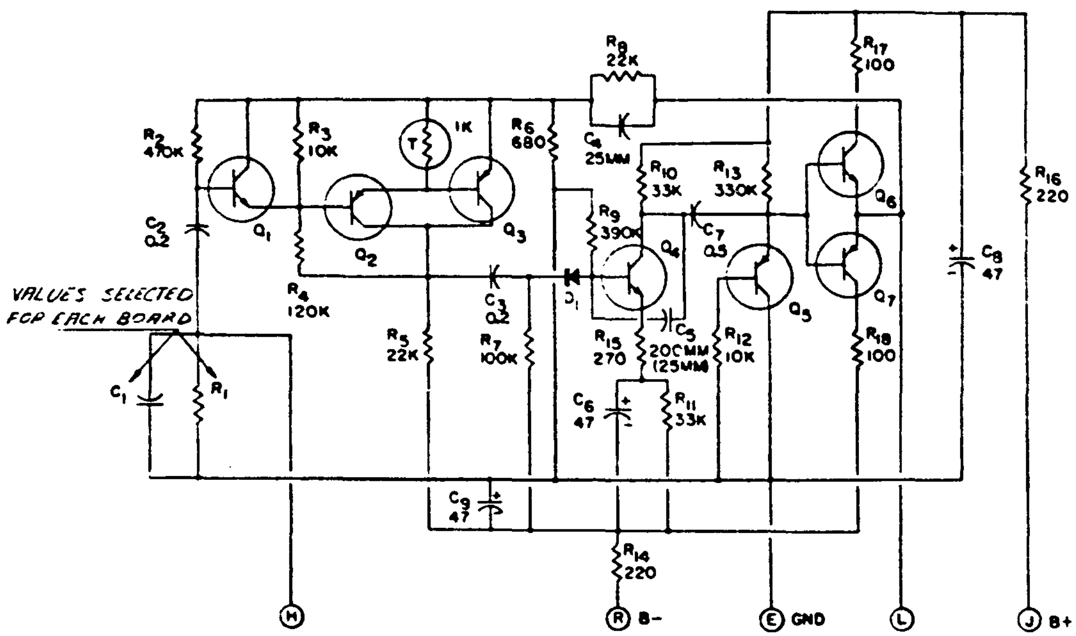
SOUTHERN RESEARCH INSTITUTE
B[illegible]M, ALABAMA

PARTICLE SIZE DISTRIBUTION ANALYZER

PHOTOMETER BOX WIRING DIAGRAM

2-5-62

1360-D-34



PARTS NAME	LIST DESCRIPTION
Q_1, Q_4	TRANSISTOR 2N169A
Q_2, Q_3, Q_5	2N[illegible]
Q_6	2N10[illegible]
Q_7	2N[illegible]
C_1, C_4, C_5	CAPACITOR CERAMIC [illegible]
C_2, C_3, C_7	[illegible] PAPER
C_6	TANTALUM [illegible]
C_8, C_9	TANTALUM [illegible]
D_1	DIODE [illegible]
$R_1 - R_8$	RESISTOR COMPOSITION 1/4 WATT 10% TOL
T	THERMISTOR FENWAL [illegible]
PLUG	ARMEL DEP-15P 06

THIS DIAGRAM IS USED FOR BOTH THE FAST AND SLOW CIRCUIT.
COMPONENT VALUES FOR BOTH ARE THE SAME EXCEPT THAT, WHERE TWO VALUES ARE SHOWN, THOSE FOR THE FAST CIRCUIT ARE IN PARENTHESES.
MM = MICROMICROFARADS
ALL VALUES IN OHMS OR MICROFARADS UNLESS OTHERWISE SPECIFIED

DATE

PARTICLE SIZE DISTRIBUTION ANALYZER

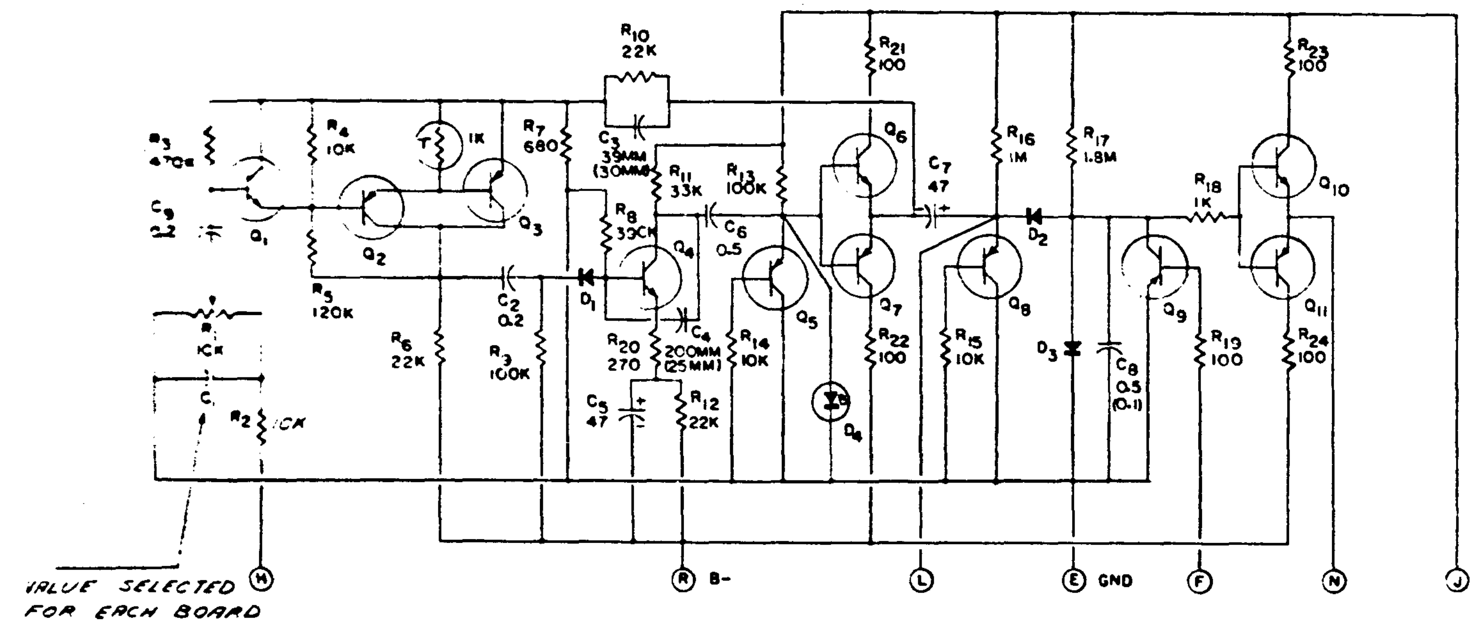
PREAMPLIFIER

RAC

J E HORN

12-29-61

1360-B-17



PARTS	LIST
NAME	DESCRIPTION
T	THERMISTER, FENWAL, KA3[illegible]
D_4	DIODE, ZENER, IN720A

PARTS	[illegible]
NAME	[illegible]
Q_1, Q_4	[illegible]
Q_2, Q_3, Q_5, Q_8, Q_9	[illegible]
Q_6, Q_{10}	[illegible]
Q_7, Q_{11}	[illegible]
C_1, C_3, C_4	[illegible] CERAMIC [illegible]
C_2, C_6, C_8	
C_9	[illegible]
C_5	TANTALUM [illegible]
C_7	TANTA[illegible]
D_1	[illegible]
D_2, D_3	DIODE, [illegible]
R_2—R_{24}	RESISTOR COMPOSITION 1/4 WATT 10% TOL
PLUG	ARMEL DEP [illegible]
R_1	POT, [illegible]

5-8-62	GENERAL REVISIONS
DATE	

SOUTH[illegible]

PARTICLE SIZE DISTRIBUTION ANALYZER

AMPLIFIER AND PEAK STORAGE UNIT

J E HORN

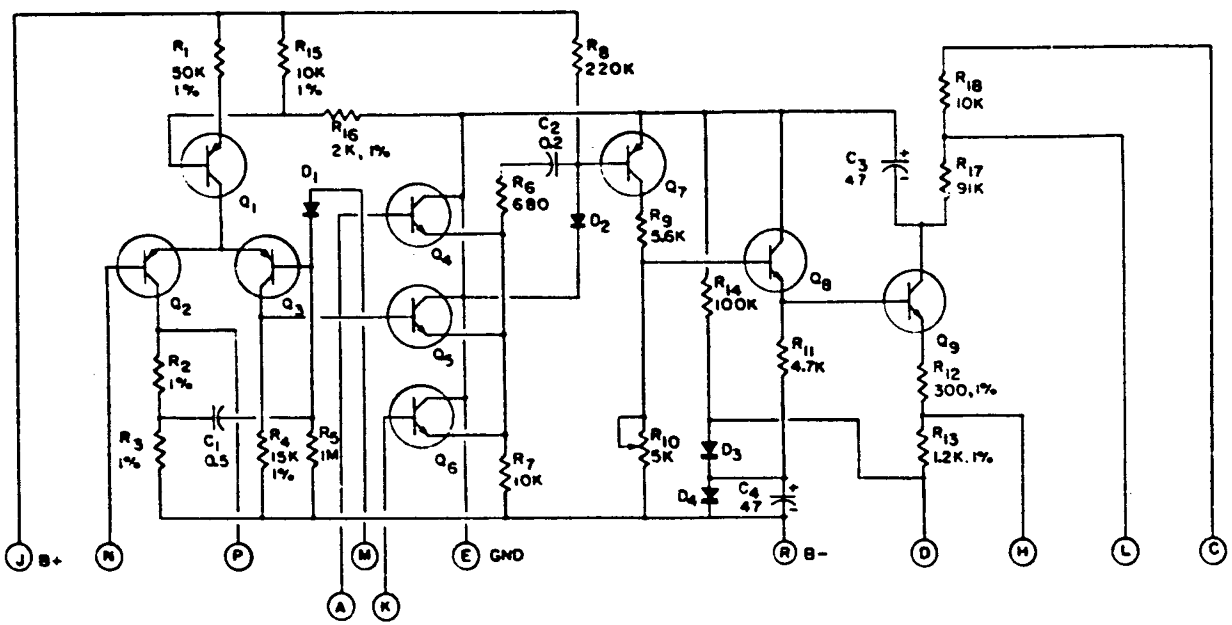
12-29-61

1360-B-19

THIS DIAGRAM IS USED FOR BOTH THE FAST AND SLOW CIRCUIT.
COMPONENT VALUES FOR BOTH ARE THE SAME EXCEPT THAT, WHERE TWO VALUES ARE SHOWN, THOSE FOR THE FAST CIRCUIT ARE IN PARENTHESES.
MM = MICROMICROFARADS.
ALL VALUES IN OHMS OR MICROFARADS UNLESS OTHERWISE SPECIFIED.

PARTS	LIST
NAME	DESCRIPTION
PLUG	ARMEL, DEP-15P-96

PARTS	
NAME	DESCRIPTION
Q_1, Q_2, Q_3, Q_7	TRAN[illegible] 2N5[illegible]
Q_4, Q_5, Q_6, Q_8	2N169A
Q_9	2N3[illegible]
C_1, C_2	[illegible]
C_3	TANTAL[illegible]
C_4	TANTAL[illegible]
D_1	DIOD[illegible]
D_2, D_3, D_4	IN 3253
$R_5 - R_9, R_{11}$, R_{14}, R_{17}, R_{18}	RESI[illegible] COMPOSIT[illegible] ON 1/4 WATT 10% TOL
R_{10}	POT [illegible]
$R_1 - R_4, R_{12}$, R_{13}, R_{15}, R_{16}	RESISTOR PRECISION 1% TOL



THE CONNECTIONS OF R18 AND R17 ARE SHOWN FOR THE TOTAL BOARDS. FOR THE CHANNEL BOARDS R17 & R18 ARE REPLACED BY A SINGLE 100K, 1% RESISTOR.

R_2=12K, R_3=3K FOR CHANNELS 1, 2, 5, 6 & TOTAL

R_2=10K, R_3=5K FOR CHANNELS 3, 4, 7 & 8

ALL VALUES IN OHMS OR MICROFARADS UNLESS OTHERWISE SPECIFIED

5-8-62	GENERAL REVISIONS
DATE	

TOLERANCES UNLESS OTHERWISE NOTED

SOUT[illegible] [illegible]STITUTE

PARTICLE SIZE DISTRIBUTION ANALYZER

PULSE HEIGHT DISCRIMINATOR, GATE, & COUNTER

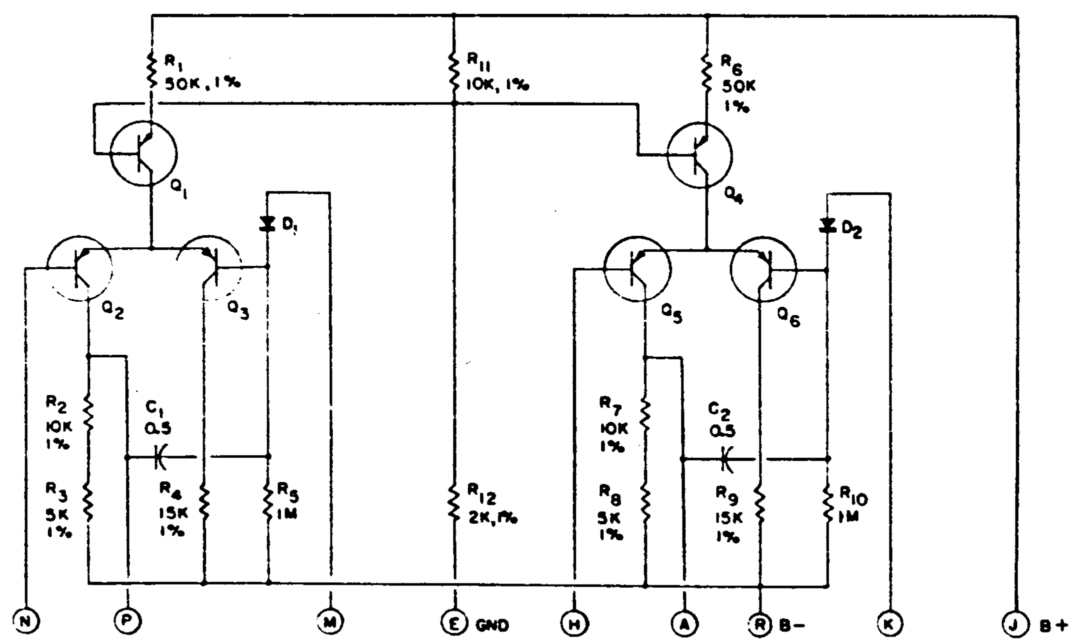
APPROVED

CHECKED

DRAWN J E HORN

12-29-61

1360-B-20

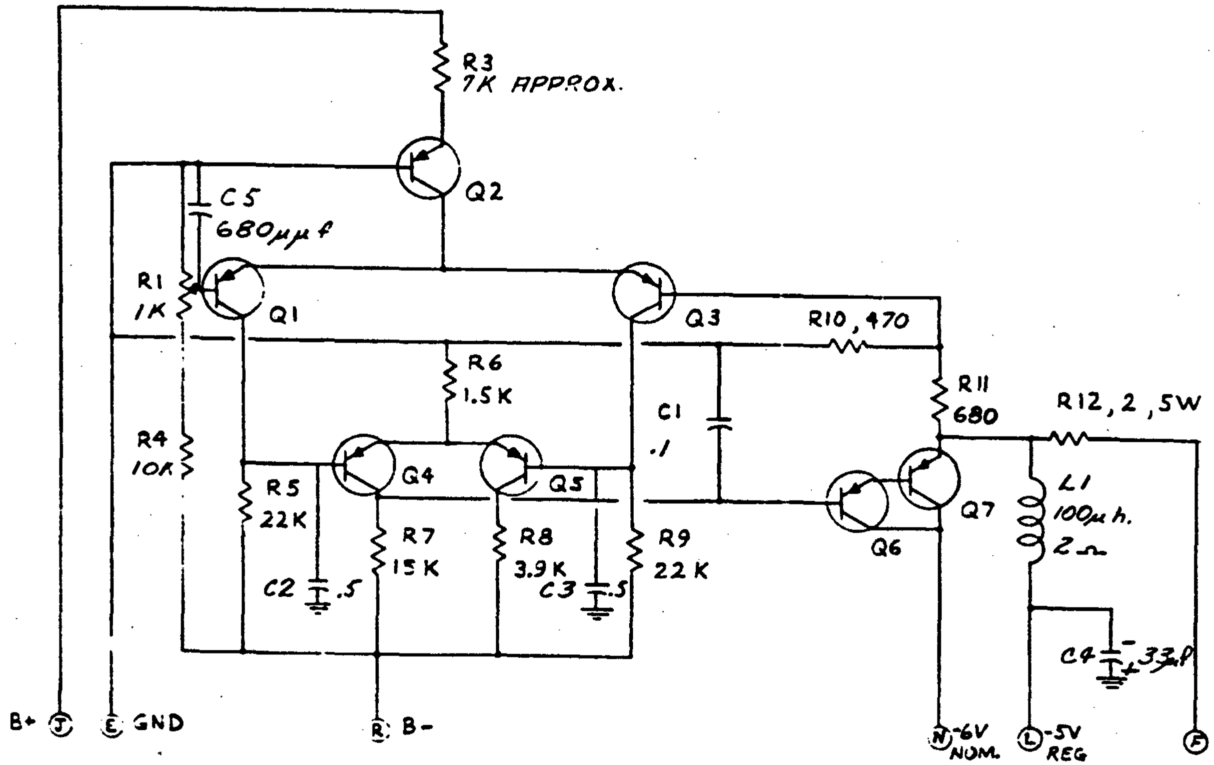


PARTS LIST	
NAME	DESCRIPTION
$Q_1, Q_2, Q_3,$ Q_4, Q_5, Q_6	TRANSISTOR 2N50?
C_1, C_2	CAPACITOR, HOPKINS,PAP??
D_1, D_2	DIODE, ????
R_5, R_{10}	RESISTOR, COMPOSITION, 1/4 WATT, 10% TOL
R_1-R_4, R_6-R_9, R_{11}, R_{12}	RESISTOR, PRECISION, 1% TOL.
PLUG	ARMEL, DEP-15P ??

ALL VALUES IN OHMS OR MICROFARADS UNLESS OTHERWISE SPECIFIED

TOLERANCES UNLESS OTHERWISE NOTED	SOUTH... INSTITUTE
	PARTICLE SIZE DISTRIBUTION ANALYZER
APPROVED	PULSE HEIGHT DISCPIMINATORS, GATE CLOSING
CHECKED	DWG. NO. 1360-B-21
DRAWN J E HORN	DATE 12-29-61

DATE | REVISIONS



PARTS LIST	
NAME	DESCRIPTION
Q1-Q6	2N508
Q7	2N456A
C1, C2, C5	HOPKINS [illegible] PAPER
C4	[illegible]
C5	TANTAL[illegible] CAPAC[illegible]
R1	POTENT[illegible] ER, BO[illegible]
R3-R6, R8-R11	COMPOS[illegible] 1/4W [illegible]
R12	W REWOUND 2 OHM [illegible]
PLUG	ARME[illegible] DEP[illegible]
L1	CHOKE [illegible] 4652

NOTE:
ALL VALUES IN OHMS OR MICROFARADS
UNLESS OTHERWISE NOTED.

DATE	REVISIONS	ZONE
5-8-62	GENERAL REVISIONS	
2-20-62	Polarity of D1 and D2 reversed	

TOLERANCES UNLESS OTHERWISE NOTED	
FRACTIONS	± 1/32
DECIMALS	± .010
ANGLES	± 1°
FINISH	
APPROVED	
CHECKED	
DRAWN	RHC

SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM 5, ALABAMA

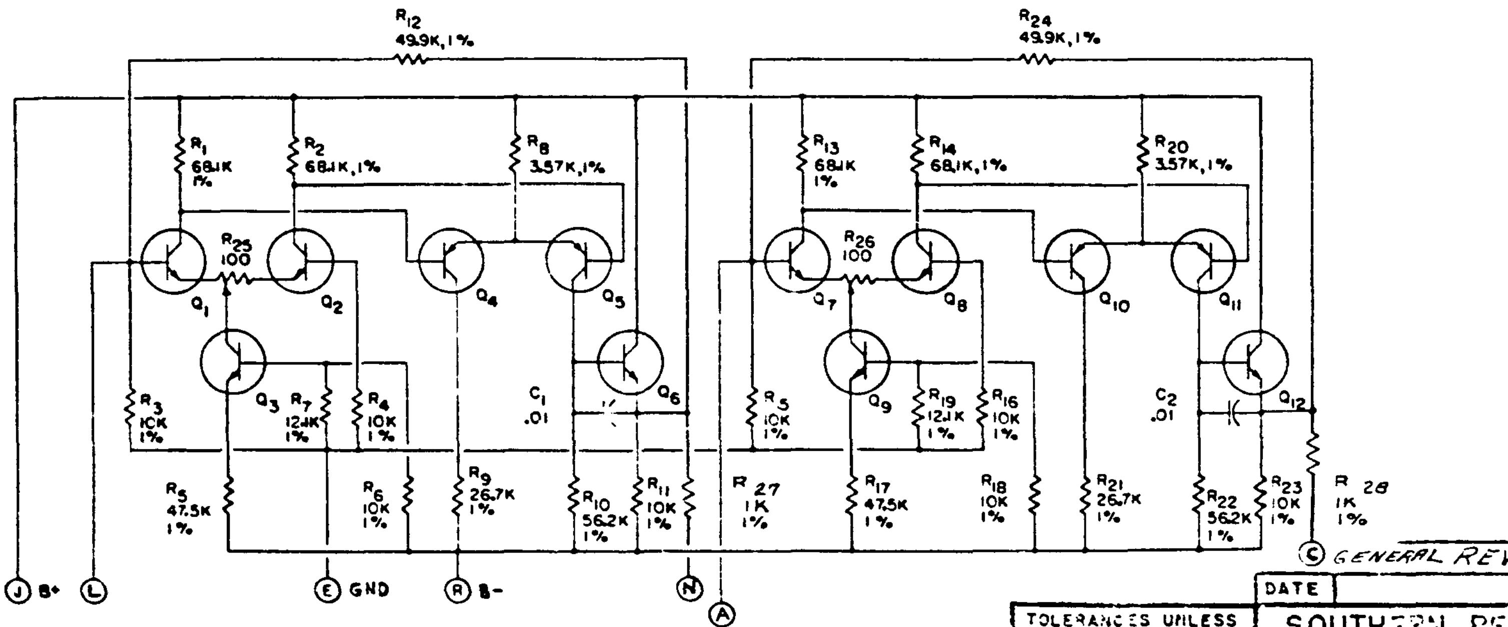
TITLE PARTICLE SIZE DISTRIBUTION ANALYZER

VOLTAGE REGULATOR

SCALE

DATE 1-6-62

DWG. NO. 1360-B-22



PARTS	LIST
NAME	DESCRIPTION
Q_1, Q_2, Q_7, Q_8	TRANSISTOR 2N753
Q_3, Q_6, Q_9, Q_{12}	2N169A
Q_4, Q_5, Q_{10}, Q_{11}	2N1131
C_1, C_2	CAPACITOR, HOPKINS, PAPER
$R_1 - R_{24}$, $R_{27} - R_{28}$	RESISTOR, PRECISION, 1/4 WATT, 1% TOL
R_{25}, R_{26}	POT, BOURNS
PLUG	ARMEL DEP-15P-96

GENERAL REVISION 5-8-62

DATE	REVISIONS

TOLERANCES UNLESS OTHERWISE NOTED

FRACTIONS ± 1/32

DECIMALS

ANGLES

FINISH

APPROVED

CHECKED

DRAWN J E HORN

SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM 5, ALABAMA

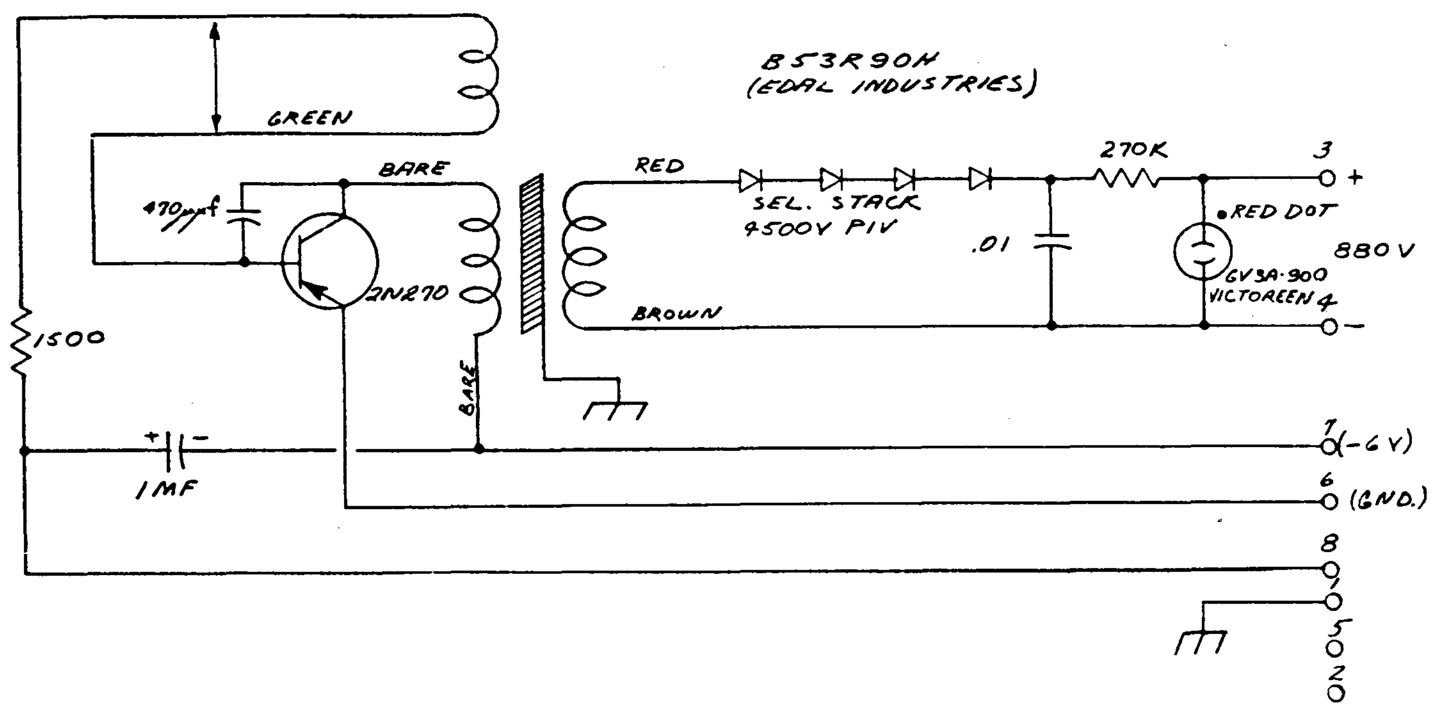
TITLE PARTICLE SIZE DISTRIBUTION ANALYZER

BUFFER AMPLIFIER

SCALE

DATE 1-8-62

DWG. NO. 1360-B-29

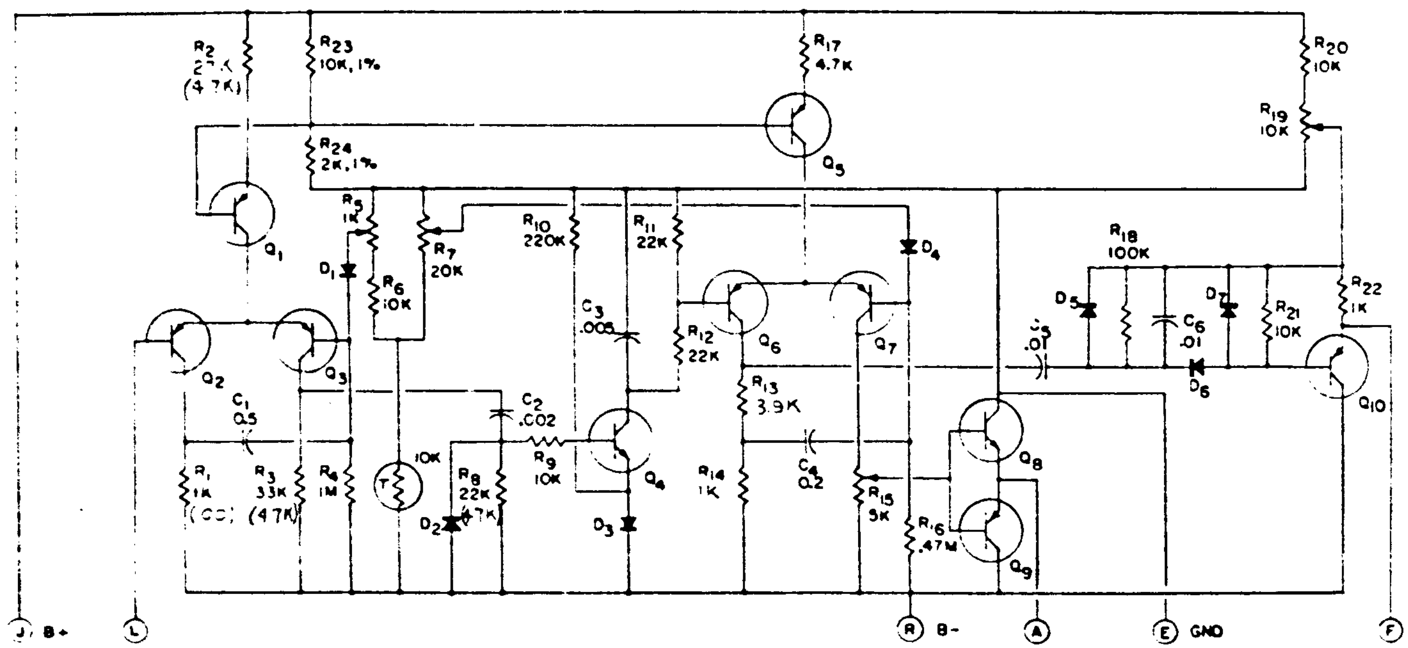


DATE	REVISIONS

TOLERANCES UNLESS OTHERWISE NOTED	SOUTHERN RESEARCH INSTITUTE BIRMINGHAM 5, ALABAMA
FRACTIONS	TITLE Components Corp. Model 73 H.V. Power Supply
DECIMALS	
ANGLES	
FINISH	
APPROVED	
CHECKED	SCALE NONE · DWG. NO. 1360-B-39
DRAWN E.A.C.	DATE 5-18-62

PARTS LIST	
NAME	DESCRIPTION
PLUG	ARMEL, DEP-15P-96

PARTS LIST	
NAME	DESCRIPTION
$Q_1, Q_2, Q_3, Q_5, Q_6, Q_7, Q_{10}$	TRANSISTOR 2N508
Q_4, Q_8	2N169A
Q_9	2N1193
C_1, C_3-C_6	CAPACITOR, HOPKINS, PAPER
C_2	AEROVOX, PAPER
D_1, D_2, D_4-D_7	DIODE, DR 185
D_3	IN3253
$R_1-R_4, R_6, R_8-R_{14}, R_{16}, R_{17}, R_{18}, R_{20}-R_{22}$	RESISTOR, COMPOSITION, 1/4 WATT, 10% TOL
R_{23}, R_{24}	PRECISION 1% TOL
R_5, R_7, R_{15}, R_{19}	POT, BOURNS
T	THERMISTER, FENWAL [illegible]



THIS DIAGRAM IS USED FOR BOTH THE FAST AND SLOW CIRCUIT. COMPONENT VALUES FOR BOTH ARE THE SAME EXCEPT THAT, WHERE TWO VALUES ARE SHOWN, THOSE FOR THE FIRST CIRCUIT ARE IN PARENTHESIS.

A. VALUES IN OHMS OR MICROFARADS UNLESS OTHERWISE SPECIFIED

DATE	REVISIONS
5-8-62	GENERAL REVISIONS

TOLERANCES UNLESS OTHERWISE NOTED

APPROVED

CHECKED

DRAWN J E HORN

SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM 5, ALABAMA

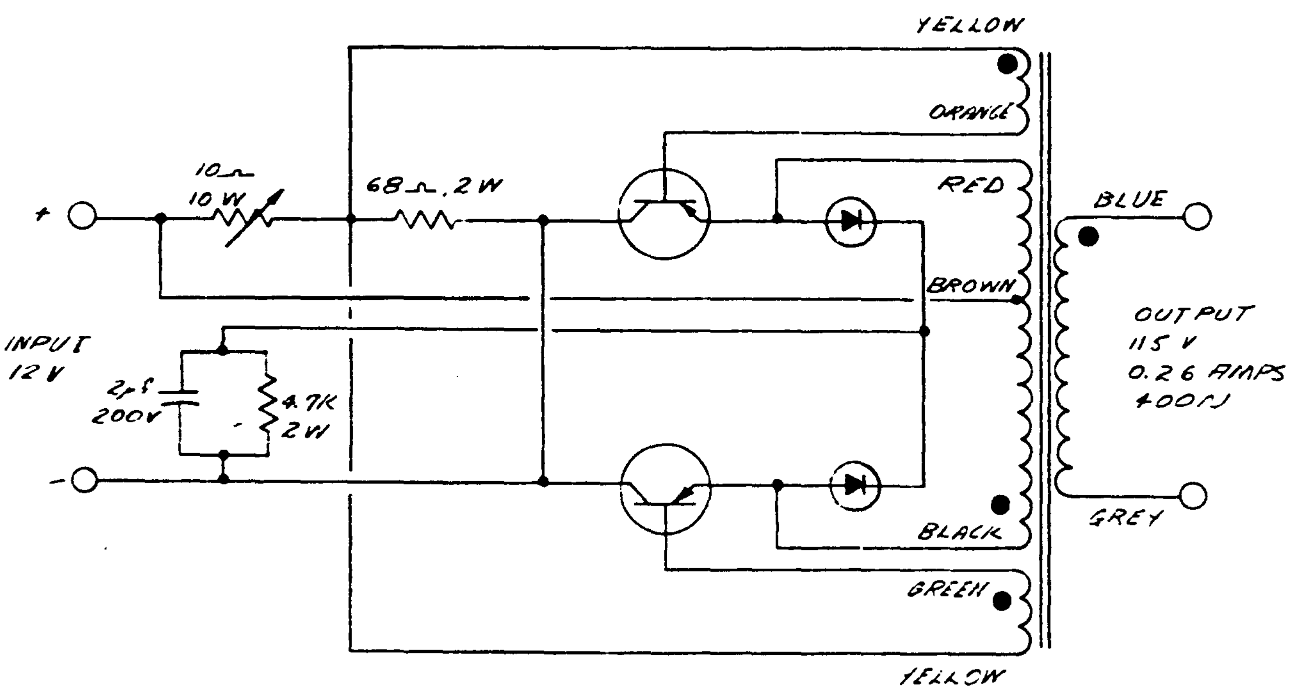
TITLE PARTICLE SIZE DISTRIBUTION ANALYZER

MAIN DISCRIMINATOR AND GATE GENERATOR

SCALE

DATE 12-29-61

DWG. NO. 1360-B-42



DATE	REVISIONS		ZONE	NO.

TOLERANCES UNLESS OTHERWISE NOTED		
FRACTIONS	± 1/32	—
DECIMALS	±.010	—
ANGLES	±1°	—
FINISH	—	—
APPROVED		
CHECKED		
DRAWN	E. A. C.	

SOUTHERN RESEARCH INSTITUTE
BIRMINGHAM 5, ALABAMA

TITLE SORENSEN INVERTER, MODEL DQI 6/115 - 0.26

SCALE NONE	DWG. NO. 1360-B-45
DATE 6-11-62	